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COAL WASHING IN ILLINOIS

BY

F. C. LINCOLN

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UNIVERSITY OF ILLINOIS
ENGINEERING EXPERIMENT STATION

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By F. C. Lincoln, Assistant Professor of Mining Engineering

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COAL WASHING IN ILLINOIS.

I. Introduction.

Coal washing is the partial purification of coal by mechanical treatment with water. It is one of a series of purifying processes to which the general term coal dressing is applied, among which are also included hand picking, mechanical picking, pneumatic separation and flotation. Coal dressing is the preparation of coal for use as a fuel or in the manufacture of coke, and comprises sizing, crushing, briqueting and purification, and combinations of two or more of these processes. Coal washing may therefore be more fully defined as that branch of coal dressing which is concerned with the partial removal of impurities from coal by mechanical treatment with water for the purpose of preparing it for use as a fuel, or in the manufacture of briquets or coke.

1. *Scope of Bulletin.*—This bulletin contains a general account of the history, practice, results and costs of coal washing in Illinois. It is a compilation of data obtained by reading, correspondence, personal interviews and field work. A period of two and one-half months was spent in the field. This time was sufficient for the inspection of all the operating coal washeries in the State and the collection of over one hundred samples.

It was too short, however, to permit of detailed studies being made of any of the washeries visited, although the value of such studies is fully realized and it is hoped they may be carried out in the future. The time was also too short for a study of the methods by which the raw screenings for the washeries were produced. Fortunately, however, mining methods in Illinois—including those parts of the State in which coal washeries are in operation—have been made the subject of an investigation undertaken jointly by the Department of Mining Engineering of the University of Illinois, the Illinois State Geological Survey and the United States Bureau of Mines. The co-operative publications on districts in which washeries are situated may profitably be consulted in connection with this bulletin.

2. *Acknowledgements.*—The investigation of Illinois washeries was suggested by Prof. H. H. Stoek of the University of Illinois, and his advice and criticisms have proved of great value. The owners and operators of washeries throughout the State have lent their assistance in arranging for the inspection of their plants and the sampling of their products. Many of them have also supplied costs, analyses and historical data which have added greatly to the value of this work. The companies engaged in the building of washeries have been most kind in supplying information. In several instances men not at present financially interested in washing operations have contributed historical details, notably Messrs. L. D. Howe, E. D. Meier and A. E. Tyler.

Pictures, drawings or cuts for some of the illustrations of this bulletin have kindly been furnished by the Allen and Garcia Co., Chicago; Allis-Chalmers Co., Chicago; American Coal Washing Co., Alton; American Concentrator Co., Joplin, Mo.; Mr. C. A. Herbert, Gen. Supt. Chicago, Wilmington and Vermilion Coal Co., Streator; Jeffrey Mfg. Co., Columbus, O.; Link-Belt Co., Chicago; and Roberts and Schaefer Co., Chicago.

Permission to employ many of the analyses in this bulletin was granted only with the understanding that they should be used in such a manner that it would be impossible to tell to what mine and washery they belonged. In order to carry out the spirit of this agreement, it has been necessary to omit specific acknowledgements of other analyses whose sources are not confidential. Some of the analyses published come from the co-operative work mentioned above, more were kindly furnished from unpublished records of the Illinois State Geological Survey and of the Commercial Testing and Engineering Company, others were copied from publications of the United States Bureau of Mines and from other works noted in the bibliography, Appendix A, while still others were obtained from private communications.

3. *Production of Coal.*—In the year 1912, 19 844 517 tons of bituminous coal were washed in the United States. This was 4.4 per cent of the total production. The washeries produced from the raw coal 17 538-572 tons, or 88.4 per cent of washed coal, and 2 305 945 tons, or 11.6 per cent of refuse. Table I shows the production of washed bituminous coal in the United States from 1906 to 1912, as published in "Mineral Resources." It will be observed that there were marked decreases in the productions of both washed and raw coals for 1911 compared with those for 1910. This was due to two causes. The principal one was the depressed state of the iron industry in 1911, leading to a smaller demand for coke for the furnaces and resulting in a decrease of about ten million tons in the quantity of coal used in the manufacture of coke. The production of washed coal was more seriously affected proportionally than that of the raw coal, since by far the larger portion of the washed coal produced is used in the manufacture of coke. The other factor in decreasing the production was the competition with California fuel oil in the Northwest. Table 2 shows the production of washed coal by States.

The washing of anthracite is an important industry in Pennsylvania, 3 533 768 short tons of washed anthracite having been produced in 1912. This was 4.8 per cent of the total production for that year. When this amount is added to the production of washed bituminous coal, the total production of washed coal for 1911 is found to be 23 378 285 tons, of which 15.1 per cent is anthracite and 84.9 per cent bituminous coal.

Out of a total production of 59 885 226 tons of coal in 1912, Illinois washed 3 522 760 tons, or 5.88 per cent This amount is greatly in

TABLE 1.

PRODUCTION OF WASHED BITUMINOUS COAL IN THE UNITED STATES IN SHORT TONS.

Year	Raw Coal Produced	Raw Coal Washed	Washed Coal Produced	Refuse	Number of States Producing
1906	342 874 867	10 425 455	9 251 946	1 173 509	17
1907	394 759 112	12 981 514	11 269 518	1 711 996	19
1908	332 573 944	13 660 478	11 870 438	1 790 040	18
1909	379 744 257	16 541 874	14 443 147	2 098 727	16
1910	417 111 142	18 395 382	16 035 387	2 359 995	21
1911	405 907 059	12 355 716	10 830 823	1 524 893	17
1912	450 104 982	19 844 517	17 538 572	2 305 945	20

TABLE 2.

BITUMINOUS COAL WASHED AT THE MINES IN 1912, WITH QUANTITY OF WASHED COAL AND OF REFUSE OBTAINED FROM IT, BY STATES, IN SHORT TONS, AND RANK OF STATES.

State	Quantity of Coal Washed	Quantity of Cleaned Coal	Quantity of Refuse	Rank of States
Alabama	7 187 211	6 325 946	861 265	1
Arkansas	72 753	50 563	22 190	15
Colorado	116 950	107 174	9 776	13
Georgia	111 923	87 300	24 623	14
Illinois	3 522 760	3 070 523	452 237	3
Indiana	18 784	17 077	1 707	19
Kentucky	164 496	150 626	13 870	9
Maryland	53 842	53 191	651	17
Michigan	128 738	113 623	15 115	12
Missouri	140 582	101 953	38 629	11
Montana	666 713	599 104	67 609	6
Ohio	336 639	305 629	31 010	8
Oklahoma	143 537	117 018	26 519	10
Oregon	12 501	10 501	2 000	20
Pennsylvania	4 819 330	4 326 162	493 168	2
Tennessee	449 847	390 994	58 853	7
Texas	25 599	20 639	4 960	18
Virginia	60 640	56 925	3 715	16
Washington	863 643	731 521	132 122	5
West Virginia	948 029	902 103	45 926	4
Total	19 844 517	17 538 572	2 305 945	

excess of the average proportion of bituminous coal washed in the United States and is about the same as the proportion of anthracite washed in Pennsylvania. There were produced 3 070 523 tons of washed coal and 452 237 tons, or 12.8 per cent, of refuse. This proportion of refuse is greater than the average for the United States, which is 11.6 per cent. Table 3 shows the production of washed coal in Illinois from 1906 to 1912. It will be noted that in the face of a greatly reduced production of washed coal for the country as a whole in 1911, Illinois made a slight increase. This was due to the fact that Illinois washes coal for direct use as fuel and not for the manufacture of coke, and that there is no competition with fuel oil, so the causes of the decreased production elsewhere were not effective in this State.

TABLE 3.

PRODUCTION OF WASHED COAL IN ILLINOIS IN SHORT TONS.

Year	Raw Coal Produced	Raw Coal Washed	Washed Coal Produced	Refuse	Rank among Coal Washing States
1906	41 480 104	2 600 817	2 216 593	384 224	2nd (Pa. 1st.)
1907	51 317 146	2 988 386	2 465 767	522 619	2nd (Ala. 1st.)
1908	47 659 690	3 768 112	3 202 264	565 848	1st
1909	50 904 990	4 064 085	3 466 097	597 988	2nd (Ala. 1st.)
1910	45 900 246	2 453 208	2 019 396	433 812	3rd (Ala. and Pa. 1st and 2nd.)
1911	53 679 118	2 553 381	2 154 697	398 684	2nd (Ala. 1st.)
1912	59 885 226	3 522 760	3 070 523	452 237	3rd (Ala. and Pa. 1st and 2nd.)

II. HISTORY OF COAL WASHING.

4. *Early History.*—In early times, the only mode of cleaning coal was to screen out the slack and throw it away and to pick the impurities out of the lump coal by hand. As competition grew, this wasteful method was in part superseded by washing, an adaptation to the purification of coal of processes long in use for the wet concentration of ores.

Coal washing was first practised in Europe, and as early as 1826 slack coal was step-washed in the valley of the Tharandt near Dresden, Saxony. The step washer was an early form of the trough washer and owed its name to the presence of two inclined planes, or "steps," in the bottom of its trough. The jigging process was applied to coal in 1837 at the St. Etienne collieries, France, hand piston jigs with capacities of 3/8 to 1/2 ton per day of 10 hours being employed. A mechanical piston jig capable of washing 80 tons in 12 hours was introduced by Berard in 1848 and rapidly came into use in France, Belgium, Germany and England. A number of other types of washers were invented shortly thereafter, and by 1860 the process of coal washing was firmly established in Europe.*

Pennsylvania anthracite was the first coal to be washed in the United States. Experiments with crude jigs were made in the vicinity of Pottsville in 1860 and 1865, and one or two small washeries were in operation prior to 1870, although the first extensive washing of anthracite was probably that undertaken by the Lehigh Coal and Navigation Co. about the year 1875.**

The washing of bituminous coal in the United States began almost

*Beckwith, A., Van Nostrand's Mag. 2, (1870), 337-350.
**H. H. Stoek, Editorial in Mines and Minerals 25, (1905), 245.

as early as that of anthracite. The first washery was built at Alpsville on the Baltimore and Ohio R. R. about 24 miles from Pittsburgh, Pa., in 1869. It was a piston jig plant with a capacity of 10 tons per hour and washed slack from the neighboring mines for conversion into coke on the spot. Mr. John J. Endres, a German mining engineer who had been employed at Prussian government mines, had charge of the construction.*

5. *Washeries in Illinois.*—The first washery in Illinois, and second bituminous washery in America, was that of the Illinois Patent Coke Co. at East St. Louis, begun in 1870 and completed in 1871. Mr. Adolphus Meier was president of the company, Mr. Joseph Lindenschmidt vice-president, and Mr. Louis Schantl had charge of the erection of the plant. The washery had a capacity of 10 tons per hour and employed the Osterspey jig,—a piston jig with differential motion and clap valves on its piston, adapted from a jig used to concentrate lead ore at Mechernich, Prussia. The washed coal produced supplied a battery of 24 Belgian coke ovens. As first erected this plant was unsatisfactory and in 1873 it was remodeled by Messrs. E. D. and J. W. Meier.

Late in 1871, Mr. Schantl erected another washery and 30 coke ovens for St. Louis capitalists at East St. Louis, Ill. This second plant never turned out any coke. In 1871 and 1872, Mr. Endres erected 6 more piston jig washing plants. Among these were two constructed in Illinois in 1872,—one at Joliet and the other at Equality. The panic of 1873-9 brought to a close this first period of washery building.

The sudden revival of business which took place in 1879 induced a second period of washery building. The Illinois Coal and Salt Co. constructed a piston jig washery with a capacity of 20 tons per hour in connection with a coke plant at St. Johns in 1880. By 1884, more washeries and coke works had been erected in Illinois, but none succeeded in reducing the sulphur sufficiently to make a high grade metallurgical coke, and the coal washing industry would have died out in Illinois had not another market for washed coal developed.

Among the washeries erected during the second period was one built by the Luther and Tyler Coal and Coke Co. on Otter Creek north of Streator, in 1883. This was a piston jig washery with a capacity of 35 tons per hour and was erected under the supervision of Mr. Endres. It was the first washery in Illinois to wash coal for fuel. The first screenings were washed on November 22, and regular operation began November 26, 1883. For over a year experiments were conducted in the hope of producing metallurgical coke from the washed coal, but without success. On account of lack of water in the dry period, this washery was moved in 1888 to the Vermilion River, south of Streator. When the Wilmington Washed Coal Co., successors to the Luther & Tyler Coal

*Diescher, S., Proc. Eng. Soc. West. Pa. 23, (1907), 202-3.

and Coke Co., put up a 27-ton jig washery on the Kankakee River opposite Wilmington in 1890, the washery on the Vermilion River was abandoned. Mr. L. D. Howe, who had been superintendent for the Luther and Tyler Coal and Coke Co., and was in charge of the new washery, invented a tub washer and installed it in place of the jigs in 1891. This was the first of a series of 6 Howe washeries erected in Illinois.

The third period of washery building in Illinois, beginning with the year 1894 when 3 fuel washeries were constructed, extends down to the present, and during this period an average of more than 3 washeries per year have been built. There were two years—1897 and 1903—when no washeries were erected; and the greatest number put up in any one year was 11 in 1907. A general view of the progress of washery building in Illinois is presented in Table 4.

6. *Luhrig Washeries.*—The first washery in the Southern coalfield was built under the supervision of Mr. Alexander Cunninghame who came from England in 1891 to introduce the coal washing system invented by Mr. C. Luhrig of Germany. The first Luhrig washery in America was erected at the City Furnace of the Sloss Iron Co. at Birmingham, Alabama, and although this washery was not at first a mechanical success, Mr. Cunninghame succeeded in interesting Mr. T. G. Warden of Chicago in the Luhrig System, with the result that the second Luhrig washer in America was constructed at the Brush Shaft, Carterville, in 1894. Since then, 11 more Luhrig washeries have been built in Illinois.

7. *Forrester Washeries.*—In 1894 two Forrester washeries were erected in the Northern coalfield by the Illinois Coal Washing Co. and employed the Forrester jig invented by Mr. W. W. Forrester of Chicago. Three similar washeries have since been erected by the same company.

8. *Pan Jig Washeries.*—Up to 1898, the only type of jig used for washing coal in Illinois was the piston jig. In that year, Mr. Ellwood A. Stewart invented a pan jig washer and erected the first Stewart washery at the Harrison mine near Murphysboro. Twenty-one other Stewart washeries have been built in the State since then, and eight American pan jig washeries have been built in Illinois beginning with that at Porterfield, near Toluca in 1904. Mr. Nicholas Shannon invented a type of pan jig which was tried out in the washery of the Bessemer Washed Coal Co. at East St. Louis in 1907, and since that time this jig has been installed in 6 washeries.

9. *Tub Washeries.*—From 1888 till 1902 the Howe was the only tub washer in Illinois. In the latter year the Wilmington Star Mining Co. erected a Robinson tub washery at Coal City, and since then 5 other Robinson plants have been constructed.

10. *Miscellaneous.*—During the third period of washery building in Illinois the following washeries have been built, in addition to those al-

TABLE 4.

PROGRESS OF WASHERY BUILDING IN ILLINOIS.

Date	Piston Jig Washeries						Pan Jig Washeries						Combined Pan and Piston Jig Washer's		Tub Washeries				Bumping Table Washer's		Trough Washer's		Summary		
	Forrester		Luhrig		Others		Stewart		American		Shannon				Howe		Robinson		Campbell		Scaife		Total No.	Ave. Cap.	Total Cap.
	No.	Cap.†	No.	Cap.	No.	Cap.	No.	Cap.	No.	Cap.	No.	Cap.	No.	Cap.	No.	Cap.	No.	Cap.	No.	Cap.	No.	Cap			
		(tons)		(tons)		(tons)		(tons)		(tons)		(tons)		(tons)		(tons)		(tons)		(tons)		(tons)		(tons)	(tons)
1870 2					4	40																	4	10	40
1880-4					5	138																	5	28	138
1888					1	40																	1	40	40
1890					1	27																	1	27	27
1891															1	30							1	30	30
1894	2	100	1	60																			3	53	160
1895	1	75																	1	20			2	48	95
1896			1	30											1	75			1	40			3	37	145
1897																							0	0	0
1898			2	110			1	75													1	10	4	49	195
1899							1	75													1	10	2	43	85
1900															1	50							1	50	50
1901	1	100			1	125	2	285											1	20			5	106	530
1902							4	380									1	50					5	86	430
1903																							0	0	0
1904			3	305			1	60	1	100					1	50							6	86	515
1905	1	75	2	325					1	140							1	75					5	123	615
1906			1	125	1	60	3	190	1	140							1	100					7	88	615
1907			2	160			4	280	3	490	1	125					1	150					11	110	1205
1908							1	50	1	280							1	50					3	127	380
Prior to 1909															2	90							2	45	90
1909							1	100					2	215									3	105	315
1910					2	40*			1	80													3	40	120
1911							3	310			1	125											4	109	435
1912							1	60					2	155**			1	120					4	84	335
Total	5	350	12	1115	15	470	22	1865	8	1230	2	250	4	370	6	295	6	545	3	80	2	20	85	78	6590

*Experimental washeries.
**Including one 5-ton experimental washery.
†Capacities are all given in tons per hour.

ready noted: 3 Campbell bumping table washeries, 2 Scaife trough washeries, 1 commercial New Century piston jig washery and 2 experimental New Century jig washeries, 1 Pittsburgh pan and piston jig washery and 1 experimental washery containing various types of coal washers. Foust piston jigs were installed in two of the Shannon washeries noted above, and are being installed in one of the Stewart washeries to wash the finer sizes of coal.

11. *Summary.*—From Table 3 it appears that at least 82 commercial washeries and 3 experimental washeries have been built in Illinois. Of these, 10 have burned, 29 have been dismantled or allowed to go to ruin and 8 are shut down, leaving 35 commercial and 3 experimental washeries in operation in the winter of 1912-1913. Further details concerning these washeries will be found in the chronology of coal washing in Illinois, Appendix B.

III. Impurities in Coal.

12. *Nature of Impurities.*—If by pure coal is meant coal free from moisture, sulphur and ash, then all coal is to some extent impure. The impurities are of two kinds: (1) Those impurities which are so intimately mixed with the coal as to form an integral part of it, and (2) those impurities which are less thoroughly mixed with the coal and do not enter into its constitution. Impurities of the first class can not be separated by mechanical means, those of the second class can. The principal separable impurities in Illinois coals are shale, fireclay, bone, pyrite, gypsum, calcite and moisture.

Fireclay is a rock formed from a rather pure mixture of the mineral kaolinite, ($Al_2O_3 . 2SiO_2 . 2H_2O$), with a little quartz, (SiO_2). A similar mixture with a lower degree of purity constitutes shale. Fireclay and shale occur in the coal beds as the filling of shrinkage cracks and faults crossing the beds; as rounded forms called "clay balls"; as partings in the beds; and as an intimate mixture with coal, forming a material intermediate between impure coal and carbonaceous shale, known as bone. Fireclay and shale from roof and floor also become mixed with the coal during the process of mining.

Pyrite, (FeS_2), also called iron pyrites and "fool's gold", is found in the coal beds in an even wider variety of forms. It occurs in individual isometric crystals in the clay and shale of faults and shrinkage cracks; in rounded shapes called "sulphur balls"; in partings; in cleavage cracks; as flakes; as minute disseminated particles known as "flour pyrites"; and finally as an intimate mixture with coal which is appropriately termed "sulphur bone", since it corresponds to the mixture of shale and coal which constitutes true bone.

Gypsum, ($CaSO_4 . 2H_2O$), and calcite, ($CaCO_3$), occur as thin laminae in cleavage cracks in the coal. The rock limestone is composed of more or less pure calcite and pieces of this may become mixed with the coal during mining.

Moisture is the term applied to the water mechanically held by the coal and does not include that which is chemically combined in kaolinite and gypsum. The coals of Illinois as mined have a high and variable percentage of moisture. Those in the southern part of the State contain from 8 to 10 per cent and those in the northern part from 12 to 16 per cent. By air drying this moisture content is reduced to from 2 to 5 per cent.

13. *Density of Impurities.*—The separation of impurities from coal by washing depends upon differences in density between coal and its impurities. The specific gravities of all the impurities are higher than that of the coal, but in varying degree. Lord* made specific gravity determinations on inch lumps of coal with a Nicholson hydrometer and secured values for Illinois coals as follows:

Town	*Clean Coal*	*Average Coal*
Lincoln	1.22	1.31
Auburn	1.24	1.28
Donkville	1.22	1.26
Germantown	1.26	1.30
Zeigler	1.31	1.33

Smith** gave the following specific gravities for substances from Mine No. 17 of the Consolidated Coal Co. near Collinsville, Ill.:

Coal	1.25
Bone	1.45—1.80
Shale ("Slate")	2.25—2.50
Coal with pyrite	3.20—3.60
Pyrite	5.00—5.20

Table 5 gives the specific gravities of a number of Illinois coals and of their impurities, obtained by the writer by using a Jolly balance on half-inch lumps. The results are in accord with the earlier determinations of Smith and Lord. It will be observed that the specific gravity of Illinois coal varies from 1.14 to 1.31, being lowest in the Northern field and highest in the Southern, but showing considerable local variation. The bone varies from 1.42 to 1.95; the shale, including fireclay, from 2.03 to 2.64; the pyrite bone has about the same specific gravity as the shale; the purest pyrite that can be obtained from partings is low in specific gravity owing to the inclusion of thin flakes of coal, the only pure pyrite found being in octahedral crystals in a fault plane; and the calcite is also low in specific gravity owing to inclusions of coal.

It is quite probable that further investigations would fill up the gaps shown in Table 5 between coal and bone and between bone and shale,

*Lord, N. W. "Experimental work conducted in the Chemical Laboratory of the United States Fuel Testing Plant at St. Louis, Mo., Jan. 1, 1905 to July 31, 1906." U. S. Bur. of Mines Bull. 28.

**Smith, C. H. "Mine No. 17, Collinsville, Ill." Mines and Minerals 28, 16-17.

TABLE 5.

SPECIFIC GRAVITIES OF ILLINOIS COALS AND IMPURITIES.*

Coal Bed	Coal Field	Town	Bright Coal	Dull Coal	Bone	Shale	Pyrite	Calcite
2	Northern	Granville	1.14—1.16	1.20—1.21		2.03—2.64		
2	"	Streator	1.15—1.20	1.20	1.42	2.50	(Bone) 2.43	
6	Danville	Danville	1.20—1.22			2.54—2.62	(Parting) 4.17	2.10
6	Central	Pana	1.21—1.22	1.24			(Crystal) 4.95	
6	"	Collinsville	1.2)	1.25—1.31			(Parting) 3.77	
6	Southern	Carterville	1.26—1.30		1.44—1.73	2.21—2.50		
6	"	Herrin	1.24—1.31		1.47—1.91	2.41—2.59		
6	"	Marion	1.24—1.28		1.47—1.95	2.26—2.47		

*The values for specific gravity here given are lower than those given by other authors and than those determined subsequently in the mining laboratory of the University of Illinois. This difference is probably due to the fact that the values here given were determined without first heating the coal in hot water to remove the air.—H. H. STOEK.

giving every gradation in composition and density from pure coal to pure shale. A similar gradation from pure coal to pure pyrite would probably also be found, and possibly gradations from coal to the other impurities also. But even if there were no such gradations in composition, there would still be particles having specific gravities from that of pure coal to that of the densest impurity, because there would be mixed particles composed of part coal and part impurity in all proportions.

The ash varies in a general way with the content of solid impurities, but the variation is not exactly proportional to the impurity content because the impurities are not composed entirely of ash but contain varying percentages of it. Approximate analyses of the two most common impurities, shale and pyrite, will serve to illustrate this:

Impurity	*Volatile Matter*	*Fixed Carbon*	*Ash*
Gray Shale from Herrin	7.19	0.93	91.88
Octahedral Pyrite Crystal from Pana	25.97	7.24	66.79

It is evident from these analyses that of the two impure pieces of coal of the same specific gravity, one with shale as the impurity and the other with pyrite, the ash would be much higher in the case of the coal containing shale. In the case of any given coal, the ratios of the various impurities present are likely to remain fairly constant so that the variation in ash will be very nearly in unison with the variation in specific gravity. Similarly, the content of British thermal units in a given coal will decrease with a fair degree of regularity with an increase in ash and specific gravity.

14. *Advantages of Removing Impurities.*—Washed coal is better than the raw coal from which it was produced because part of the impurities which were present in the raw coal have been removed. All the impurities mentioned in Section 12, with the exception of moisture, may be removed to a greater or less degree by washing. The general advantages of removing these impurities from coal which is to be used for fuel are:

(1) Freight and haulage do not have to be paid on waste material which has been removed by washing.
(2) The fuel value of the coal is increased so that the required charge is less and firing is therefore easier.
(3) The coal burns more freely and with less production of smoke and soot, thus increasing its efficiency.
(4) The percentage of ash is decreased and the removal of the ashes and their ultimate disposal are therefore easier.
(5) The clinkering properties of the ash are decreased, thus improving the efficiency of the fuel and the ease of removing the ashes.

In addition to the advantages just mentioned, the removal of shale, fireclay, and bone has the further advantage that with them is removed their water of constitution which would otherwise require sufficient heat to free it from chemical combination and change it to steam. If the coal is to be used in coke manufacture, it may be necessary to remove the shale and fireclay, owing to a common requirement of not over 10 per cent ash in a metallurgical coke. The removal of these impurities before coking is also desirable, because it decreases the amount of fine coke, or "breeze," formed. Unlike the other impurities in coal, pyrite is combustible and generates considerable heat. Its disadvantages, however, more than offset this advantage. In burning it forms sulphur dioxide, a gas which corrodes fire grates and boilers, and ferric oxide, a solid which is an active agent in bringing about the clinkering of ash. In coking, only a portion of the sulphur is driven from the pyrite, a very serious matter when one considers that one per cent. of sulphur is commonly the maximum permitted in a coke to be used for smelting iron. Calcite and gypsum are not very actively harmful when present in a fuel, although the former requires heat to liberate its carbon dioxide, and the latter heat to free and gasify its water; but gypsum is undesirable when the coal is to be coked, since all its sulphur will enter the coke.

IV. CRUSHING.

15. *Objects of Crushing.*—Crushing is the reduction in size of material by the application of mechanical force. The crushing of bituminous coal may conveniently be divided into coarse crushing and fine crushing. Coarse crushing may be defined as the breaking of coal to a maximum size of more than ¾ in., and fine crushing to a maximum size of ¾ in. or less. Coarse crushing is commonly employed when coal is to be used for fuel, and fine crushing when it is to be used in the manufacture of coke.

Crushing in connection with washing may have for its object the freeing of attached particles of coal and impurities, or the production of small sizes to meet a demand for them. Crushing to produce small sizes of washed coal is not at present practised in Illinois, but Bement,* commenting upon the increasing demand for washed sizes Nos. 4 and 5, states that if this increase continues they will soon command a higher price than the larger sizes. In that event, the practice will undoubtedly be introduced.

Crushing to free impurities may be applied to the raw coal prior to washing, or to the refuse as a preliminary to re-washing. Flakes, balls, bands and strata of impurities adhere tightly to the coal as it lies in the ground. During the process of mining, the coal and impurities

*Bement, A. "The Screening Problem in Illinois." Coal Age 1. (1912) 1105.

become broken apart to a greater or less extent, and this is all the crushing that the screenings sent to Illinois washeries usually receive. Lump or run of mine is crushed and washed at some mines when the coal becomes temporarily more impure than usual.

Coarse crushers for reducing the size of the lump or run of mine to the maximum size washed have been installed in five of the commercial washeries at present operating in Illinois. When washing coal for coke, a greater reduction of ash and impurities is desirable than when washing it for fuel, so in two experimental coal washeries fine crushing is employed in order to free more of the impurities than would coarse crushing.

When large sizes of coal are washed, fair-sized pieces of good coal attached to pieces of impurities are carried into the refuse. By re-crushing and re-washing the refuse, a considerable amount of this coal may be recovered. This process was successfully introduced into one Illinois washery in the fall of 1912.

16. *Toothed Rolls.*—The crushers used for reducing refuse, and four of the five crushers employed in Illinois for breaking mine run and lump, are toothed rolls, consisting of two cylinders which rotate toward one another, as looked at from above, and are provided with projecting teeth which nip and crush the material fed to them. When this material is coal, about the same proportion of different sizes are produced as in the process of mining, if the following results obtained at a washery in southern Illinois on coal from Bed No. 6 are typical:

	No. 1 Extra	*No. 1*	*No. 2*	*No. 3*	*No. 4*	*No. 5*
Produced by mining	9.0 %	15.8 %	12.4 %	15.6 %	27.2 %	20.0 %
Produced by crushing	10.0%	17.2 %	15.0 %	9.7 %	29.7 %	18.4 %

No figures were obtainable as to the capacities and power consumptions of the rolls used for crushing coal in Illinois. The pair of toothed rolls crushing refuse worked on material between 3 in. and ¾ in. in size reducing it to less than ¾ in. They were 18 inches long and 18 inches in diameter and treated about 7 tons per hour.

One single-roll crusher is installed in an Illinois washery to do coarse crushing. The single roll crusher instead of having two toothed rolls rotating toward each other, as in the ordinary coal rolls, consists of a single toothed roll rotating toward a fixed plate.

The hammer pulverizer is well adapted to the fine crushing of coal. It consists of a number of hammers attached loosely to a shaft which is rotated at high speed. The hammers strike the coal in the air and crush it largely by impact. A Williams No. 00 hammer pulverizer was found to reduce Illinois coal to ⅜ in. at the rate of 1¼ tons per hour when running at 2200 r. p. m. A Pennsylvania crusher required 75 k. w. to reduce 75 tons of dry Pocahontas coal per hour from mine run to ¾ in. Fifteen per cent. less dry Illinois coal could be put through per hour under the same conditions, and when this coal contained from 9 to 12 per cent. moisture only 50 tons per hour could be crushed, making the power consumption 1.5 k. w. per ton moist Illinois coal per hour.

V. Sizing Raw Coal.

17. *Sizing* is the separation of material into groups of particles lying within distinct ranges in size. When sizing is perfect, these groups do not overlap, but consist wholly of particles whose sizes lie within some definite range and are all smaller than those in the group above and larger than those in the group below.

Sizing is usually effected by means of screens made of bars, woven wire or perforated metal. The screens in use in Illinois washeries may be classified as follows:

CLASSIFICATION OF SCREENS.

Fixed	*Moving*
Gravity Screens	Revolving Screens { (Cylindrical) (Conical)
Drag Screens	Shaking Screens

18. *Fixed Screens* are constructed of bars or perforated metal forming a plane surface over which coal may slide by gravity ("gravity screens"), or be drawn by a scraper ("drag screens"). Gravity screens are inclined so that coal runs down hill over them, the larger pieces passing over the openings and the smaller pieces through them. They are placed in the bottom of chutes to relieve or supplement overloaded screens of other types, to remove chippings or to drain off water. Drag screens are either level or inclined, the coal being dragged up hill in the latter case. They are used for separating the two finest sizes of washed coal, for rinsing, and in one instance for preliminary sizing. No headroom is lost by their use—head being actually gained when they are inclined—and in this respect they are superior to moving screens, but they have the disadvantage in common with gravity screens that they do not stir up the coal as thoroughly as the moving screens and so are not as efficient.

19. *Revolving Screens.*—Moving screens are used in washeries for all sorts of sizing. Revolving screens are made of woven wire or perforated metal, bent to the shape of a hollow cylinder ("cylindrical revolving screens"), or the frustum of a cone ("conical revolving screens"). Cylindrical revolving screens are supported upon spiders extending from a central shaft or upon exterior rings resting on rollers, and are revolved by gears. They are mounted with a slight inclination which, combined with their rotation, causes the coal fed in at the high end, which does not pass through the openings in the screen, to be discharged at the lower end. Conical revolving screens are usually mounted with their

axes level and thus have simpler bearings than cylindrical screens. The movement of the coal over them is due to the downward slope of the bottom of the screen caused by the increasing diameter of the frustum of the cone, assisted, as in the cylindrical screen, by the revolution of the screen.

Two or three revolving screens of different diameters are sometimes arranged concentrically upon the same shaft, when the screen is said to be "double-jacketed" or "triple jacketed." Such an arrangement is not only economical of space and power, but it enables the coarser sizes to be removed first, so that they need not pass over the fine screen, which is the one most readily worn out. The disadvantages are that since the outer screen rotates more rapidly than the inner, when it is going at the proper speed the inner one is not going fast enough; again, since the outer screen is larger than the inner one but has less material to screen, if the inner screen is big enough the outer one will be too large; and, finally, the construction renders it difficult to clean and repair the inner screen or screens. These particular disadvantages are overcome by arranging a series of cylindrical revolving screens of the same diameter close together upon the same shaft, but unfortunately other disadvantages arise. More space and heavier shafting are required and since all the coal passes over the fine screen it wears out rapidly. Moreover, this screen must be longer than in the preceding case since it has more work to do.

20. *Shaking Screens* are of perforated metal forming a plane surface which is given a rapid reciprocal motion by means of eccentrics. They may be supported on rollers below, hung from rods above, or supported above or below by means of planks rigidly attached to the screen frame. The form of shaker with the planks placed below is called the Parrish screen and not only are its supports of wood fastened tightly to the frame, but its eccentric rods are also of wood and also firmly secured to the body of the screen. This wooden construction makes the Parrish screen light, while the rigid attachment of planks and rods results in a sharp upward jerk on each stroke of the screen which is very effective. Shaking screens are more efficient per square foot of screening surface than revolving screens, occupy less space, and are more readily cleaned and repaired. Their great disadvantage lies in the fact that they can not be perfectly balanced under all conditions of load, and so they are apt to cause harmful vibration of the framework of the washery. This effect may be reduced by mounting the shaking screens in pairs moving in opposite directions.

21. *Object of Sizing.*—Sizing in connection with coal washing is employed before washing, after washing, or both before and after. Sizing after washing is discussed in Chapter VII, the present chapter being concerned with sizing raw coal only. The object of sizing before

washing is to make possible a better separation of coal from impurities on the washing machines. When the impurities have specific gravities much higher than that of the coal and are not attached to the coal, a good separation may be made without preliminary sizing, but if the impurities are but slightly higher in specific gravity than the coal, or are firmly attached to it, preliminary sizing is essential to effective washing. The reason for this will become clear when the theory of washing given in the next chapter is considered.

In Illinois, preliminary sizing is employed in 10 out of 32 operating commercial washeries. This includes six piston jig washeries—which is all but one of the washeries of this type; two pan jig washeries—which is but one-tenth of the washeries of this type; one combined pan and piston jig washery, and one bumping table washery, as shown in Table 6. Two sizes are made in three washeries, three sizes in one, four sizes in five washeries and five sizes in the remaining washery. In six cases the smallest size washed is through a ¾ in. round hole; in four cases a size between ¾ in. and 1 in. is washed; in three a size between 1 in. and 1¾ in.; and in two a size between 1¾ in. and 3 in. It is evident that preliminary sizing is very irregular in Illinois, especially of the larger sizes. Theoretically, in order that similar results shall be achieved when washing different sizes, the screen scale (or sizes of openings of successive screens) must have a constant geometrical ratio. For example, with a ratio of two the sizes of openings might be ¼ in., ½ in., 1 in., 2 in., and 4 in. An examination of Table 6 will show that no screen scale

TABLE 6.

PRELIMINARY SIZING IN ILLINOIS.

Washery Type	Reference No.	Sizes Made		Screens Employed	
		No.	Dimensions in Inches	Type	Ref. No.
Pan Jig	C.2	2	1⅛*—¾, sq., ¾ sq.—0	Cylindrical	E III a 1
"	20	2	3—$\frac{9}{16}$ sq., $\frac{9}{16}$ sq.—0	"	3
Pan and Piston Jig	35	2	3—¾, ¾—0	Conical	12
Piston Jig.......	19	4	3—1¾, 1¾—1, 1—¾, ¾—0	Triple Jacketed Cylindrical	2
"	24	4	"	Triple Jacketed Conical	4
"	28	4	3—2, 2—1, 1—¾, ¾—0	Triple Jacketed Cylindrical	5
"	29	4	3—1¾, 1¾—1, 1—¾, ¾—0	"	6
			"	"	7
"	32	4	¾—0	Shaking	E II a 1
			"	"	2
			3½—2¾, 2¾—1¾, 1¾—¾	Cylindrical	E III a 8
			"	"	9
"	34	5	1¾-1, 1—¾, ¾—0	Conical	10
			3½—3, 3—1¾	Double Jacketed Cylindrical	11
Bumping Table	30	3	3¾—1¾ slot, 1¾—⅜ slot, ⅜—0	Drag	E I a 1

*All sizes made thru round holes unless otherwise specified.

with constant geometrical ratio is at present in use for preliminary sizing in Illinois. Revolving screens are in use for sizing raw coal in all but one of the washeries. Cylindrical revolving screens only are in use in six washeries, shaker screens supplement the cylindrical screen in one washery, one has both a conical and cylindrical screen, and one a conical screen only. The washery which sizes before washing entirely without the aid of revolving screens employs a drag screen, which is traversed by scrapers running at the rate of 180 ft. per minute. The first section of this screen receives 3¾ in. screenings and is perforated with ⅜ in. round holes. When the washery is running at its rated capacity this screen treats one ton of coal per hour for each 0.2 sq. ft. of screening surface. Examination of the screen in action shows that it is too small for the work.

The two shaking screens treating raw coal make 132 shakes perminute and screen 52 per cent of ¾ in. coal out of 3½ in. screenings at the rate of one ton per hour for each 0.7 sq. ft. of screening surface. The Coal and Metal Miners' Pocket Book gives the capacity of ¾ in. shaking screens working on bituminous coal as one ton per hour per 0.63 to 0.83 sq. ft. of screening surface,* of which 0.7 is about the average, but in anthracite practice a much larger screening surface is employed.

There are twelve revolving screens sizing raw coal in Illinois washeries, nine of which are cylindrical and three conical. Of these screens, one is a simple cylndrical and one a simple conical, two are single-jacketed cylindrical screens making two sizes, one is a double-jacketed cylindrical, and four are triple-jacketed cylindrical, while the remaining two are triple-jacketed conical revolving screens. The cylndrical screens have slopes ranging from three to seven degrees, with an average of five degrees, and the conical screens all have their axes level. The number of revolutions per minute varies from seven to thirty, giving peripheral speeds ranging from 126 to 471, with an average of 219 ft. per minute. The Coal and Metal Miners' Pocket Book‡ states that the peripheral speed of anthracite screens should be about 200, and Sterling** says that it should not exceed 250 ft. per minute. Thus while the average speed of these screens appears to be about right, seven out of the twenty-seven screening surfaces under consideration have speeds above what is considered good practice in anthracite preparation. The square feet of screen surface per ton treated per hour varies from 1.0 to 11.3 with an average of 4.2. F. E. Brackett† holds that this ratio should be 8 when the mesh is ¾ in. and 16 when it is ¼ in., indicating that the raw coal screens in Illinois are not as large as elsewhere in the United States.

Further details concerning the various screens enumerated above may be found in Appendix E, Parts Ia, IIa and IIIa.

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*8th Edition, (1904) 433.
‡Page 434.
**Bul. Am. Inst. Min. Eng. 58, (1911) 762.
†Coal Age 3, (1913) 131.

VI. Washing.

A. Theory.

22. *Free Settling Ratio.*—If a piece of coal and a piece of shale of the same size and shape are dropped into water at the same time, the shale will reach the bottom first, because its weight is greater than that of the coal and the surface it presents to the water to be acted on by friction is similar. If the same piece of coal is dropped into water with successively smaller particles of shale of the same shape, the difference in time of fall will be reduced because the proportion of surface to weight, and therefore the friction per unit of weight, increases with decrease in size. Finally a particle of shale will be found of such a size that it will settle at the same rate as the piece of coal. The ratio of the diameters of this coal and shale will be inversely as the ratio of their weights in water. Expressed as a formula, this becomes

$$\frac{D}{D'} = \frac{S'-1}{S-1} \tag{1}$$

where D is the diameter of the coal, S its specific gravity, D′ the diameter of the shale and S′ its specific gravity. For example, if coal has a specific gravity of 1.2 and shale a specific gravity of 2.4, the ratio is 7, which means that a particle of this coal with a diameter of 7 will settle at the same rate as a similarly shaped piece of shale with a diameter of 1. The average particle of shale is flatter than the average particle of coal, so when pieces of coal and shale which have been sized on screens are allowed to fall through water the shale will present a larger surface in proportion to volume than the coal and the ratio will therefore be less than if the grains were of the same shape. Experimentally, the equal-falling ratio, under free settling conditions, has been found by the writer to be about 6. In a similar manner, free settling ratios may be determined for all the impurities in coal.

23. *Trough Washer.*—When particles of coal and impurities are dropped into a stream of water moving horizontally, they will describe parabolas. The more rapidly falling particles will reach the bottom first after the shortest exposure to the horizontal force of the stream and will therefore have been carried the shortest distance, while the more slowly falling particles will have been carried a greater distance. Thus a horizontal stream divides a group of particles of different sizes and specific gravities into groups of equal-falling particles of various sizes, the size divisions being determined by distance from the point of introduction of the particles. This principle is used in the trough washer. A trough is constructed of such a length and operates with such a stream of water that the largest particle of coal treated will be

carried just the full length of the trough. With it will be carried equal-settling particles of all impurities together with all smaller sizes of impurities and all the coal, while all pieces of impurities larger than those which are equal-settling with the largest coal will remain in the trough, to be removed and disposed of as refuse. No trough washers are at present employed for washing coal in Illinois, but a modified form of trough washer is in use at one washery to remove pyrite from the circulating water.

24. *Grading Box.*—The grading box employed in the Luhrig system of coal washing makes use of the same principle, but in a different manner. The grading box is a trough with openings in its bottom at intervals, through which groups of particles which are equal-falling under free settling conditions are drawn off. The continuous removal of a portion of the stream with each group of grains decreases the strength of the current and results in a more rapid dropping of the particles than if the velocity of the stream remained constant, as in the trough washer. The object of the grading box is not to produce a finished product but to prepare the raw coal for further treatment on a series of jigs.

25. *Hindered Settling.*—If a crowded mass of particles of coal and impurities of different shapes and sizes is subjected to a rising current of water which is not so swift as their free settling velocities and so will not carry them away, but yet is strong enough to keep them in motion, they will arrange themselves in layers having definite ratios dependent upon their specific gravities and shapes. The ratios are larger than for the same particles under free settling conditions and are called hindered settling ratios. This increase in ratios may be explained on the ground that under hindered settling conditions the classification is brought about by means of a quicksand which is of higher specific gravity than water, but otherwise works in a similar way. The formula for ratios then becomes

$$\frac{D}{D'} = \frac{S' - s}{S - s} \tag{2}$$

with the letters D, D′, S and S′ having the same meaning as in the formula for free settling ratios and s being the specific gravity of the quicksand. Again, considering the coal of 1.2 specific gravity and the shale of 2.4, and supposing the mixture of coal, shale and water forming the quicksand to have a specific gravity of 1.1, the hindered settling ratio is 13 where the free settling ratio was only 7; or, correcting for the difference in shape between coal and shale, 11, where the free settling ratio was only 6. In all the washers in use in Illinois—tubs, jigs and bumping tables—the washing takes place under hindered settling conditions.

26. *Tub Washer.*—The tub washer is the simplest form of hindered settling washer. It consists of a hollow, inverted cone at the bottom of which a rising current is introduced, which, with the help of mechanical stirrers, keeps the mixture of coal and impurities agitated. The larger impurities settle to the bottom, where they are drawn off intermittently, while the coal and smaller impurities which are equal-settling with the coal under hindered settling conditions are discharged continuously at the top.

27. *Jig.*—In the jig, hindered settling conditions are attained by an intermittent rising current, a succession of pulsions, or by alternating rising and falling currents, pulsions and suctions. The currents pass through a screen upon which the material to be treated rests, and are either produced by the movement of a piston, in piston jigs, or by the movement of the screen in pan jigs. The coal is discharged continuously at the top and the refuse either continuously or intermittently at the bottom. In order that the water shall work evenly over the whole area of the jig, it is necessary that a thin, loose layer of the impurities mixed with the coal be maintained over the screen, a natural bed, or if this is undesirable, a thin layer of fragments of some foreign substance like feldspar, an artificial bed. The art of jigging depends largely upon keeping the bed regular and open so that the currents of water shall rise freely through the material with equal velocities in all parts of the jig.

28. *Bumping Table.*—In the bumping table, hindered settling conditions are induced by subjecting the wet material resting on an inclined table to a succession of bumps tending to move the material up the table. The material becomes stratified in equal-settling layers. The upper layers, containing big pieces of coal and small particles of impurities, are washed off the lower end of the table by the stream of water, while the lower layers, containing the large particles of impurities, are bumped up the table and off at the top.

B. TUB WASHERS.

Tub washers were in operation in five Illinois washeries in the fall of 1912. Two commercial washeries employed Robinson tubs, two used Howe tubs and one experimental washery was testing the Richards-Janney classifier. The construction and operation of these machines is described in this section, but the results obtained at commercial tub washer plants are not given, nor are the results at other types of commercial washeries given in the succeeding sections, as such results show the action of the washery as a whole and not of the washing machines alone. For this reason results of washing are not given until Chapter X, which comes after the arrangement of washeries has been discussed.

29. *Robinson Washer.*—The Robinson tub washer, shown in section in Figure I, has a washing chamber shaped like the inverted frustum of a cone, attached at the bottom to a cylindrical refuse chamber which has valves at top and bottom.

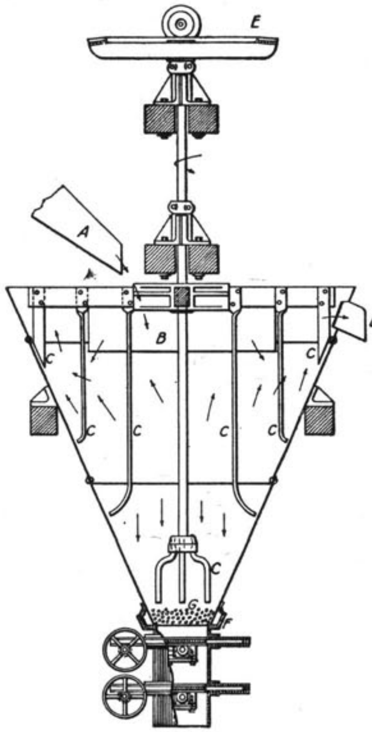


FIG. 1. ROBINSON TUB WASHER.

Raw coal is fed through the chute, A, into the center of the ring, B, while water under pressure enters the housing, F, and passes through the perforations, G, into the washing chamber. There coal and water are thoroughly mixed by the vertical stirring arms, C, driven by a gear from above. Hindered settling conditions are thus set up, causing the washed coal to rise and pass off with the water at D and the refuse to sink into the refuse chamber whose upper valve is left open. When it is desired to remove the refuse, this may be done without interfering with the operation of the tub by temporarily closing the upper valve and opening the lower one, when the refuse which has accumulated in the refuse chamber will be discharged.

The Robinson tubs in Illinois are 10½ ft. in diameter and 10½ ft. in height with 2 ft. discharge. Their rated capacity is 50 tons unsized raw coal per hour. At one washery they are run at 20 r. p. m. and at the other at 24. In order to increase the refuse storage capacity of the tub, a second refuse chamber and third valve have been added at one washery.

30. *Howe Washer.*—A sectional view of the Howe tub washer is shown in Fig. 2. It differs from the Robinson washer mainly in that it has horizontal instead of vertical stirrers.

The Howe tub at one washery is 9½ ft. in diameter and 8 ft. in height. It is run at 20 r. p. m. and has a rated capacity of 50 tons unsized raw screenings per hour. At the other washery the tub is 8½ ft. in diameter and the stirring arms are given 18 r. p. m.

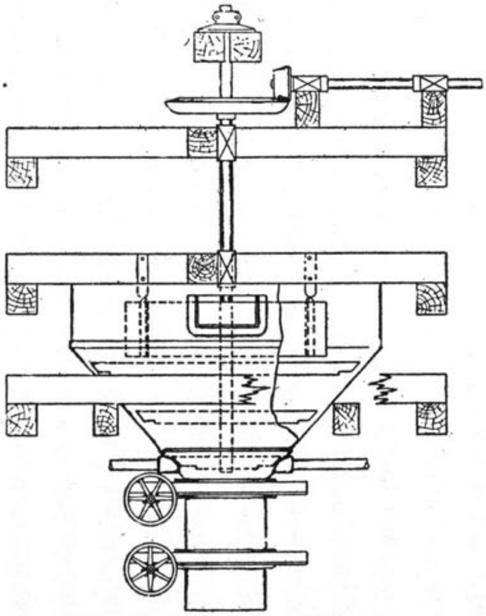


FIG. 2. HOWE TUB WASHER.

31. *Richards-Janney Classifier.*—The Richards-Janney classifier is shown in Figs. 3 and 4. Essentially it is a series of rectangular compartments (A) of increasing size each with a tub washer (B) having horizontal stirring arms like the Howe at its bottom. These washers differ from the Howe mainly in the valve employed. There is a single valve (C) above the refuse chamber (D), which is opened automatically at definite intervals, and in place of the lower valve a small opening or spigot (E) exists at the bottom of the refuse chamber, which permits the refuse discharged from the washing chamber to run away slowly and continuously. The action of the rectangular compartments

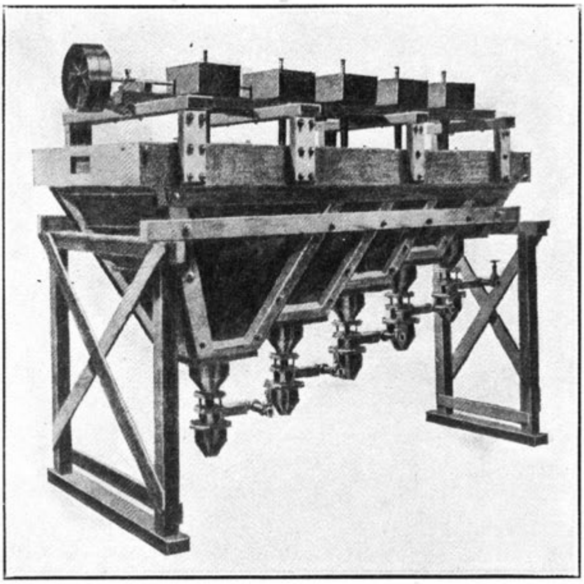


FIG. 3. FIVE COMPARTMENT RICHARDS JANNEY CLASSIFIER.

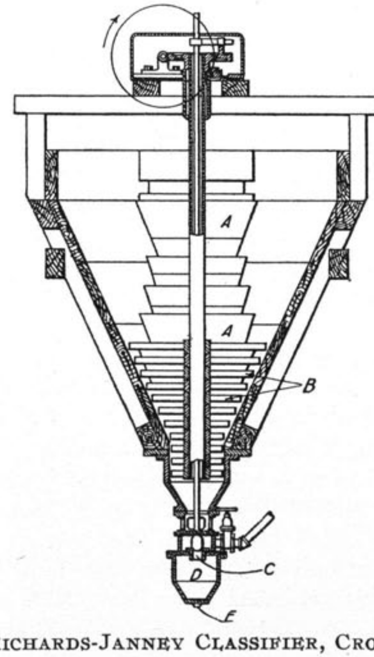


FIG. 4. RICHARDS-JANNEY CLASSIFIER, CROSS SECTION.

above the tub washers is that of a free settling classifier, or in other words these compartments deliver products which have been classified under free settling conditions to the tub washers, where they are reclassified under the more favorable hindered settling conditions. The Richards-Janney classifier is made in a small size capable of handling coal up to 3/8 in. in diameter only, and its stirring arms are run at a speed of 80 to 90 r. p. m.

Experimental work with a five-compartment Richards-Janney classifier demonstrated that a good separation could be made with the first three compartments. From the first spigot pure refuse was drawn off, from the second and third "second grade coal"—that is, coal of low grade but sufficiently good for use about the plant, a product similar to the "middlings" product of ore-dressing mills; while washed coal came from the fourth and fifth spigots and from an extra rotating valve. No water was supplied to the last two compartments, so their only function was to dewater the washed coal. The machine treated from five to six tons of raw coal per hour with a water consumption of 14000 to 20-000 gallons supplied under a pressure of 25 pounds, with a power consumption of a fraction of a horsepower. It is said that in treating an Illinois coal containing 14 per cent ash and 2.70 per cent sulphur, washed coal is obtained with about 8 per cent ash and 1.70 per cent sulphur, a small amount of secondary coal with about 16 per cent ash and 3 per cent sulphur, and refuse with 70 per cent ash and 13 per cent sulphur.

C. PISTON JIGS.

In the fall of 1912, piston jig washers were in operation in eight commercial and two experimental washeries in Illinois. They were the second in number among the classes of washers in use, being only exceeded by the pan jigs. The types represented were the Luhrig jig, the Forrester jig, the New Century jig and the Foust jig.

32. *Luhrig Jig.*—Luhrig jigs are single-compartment jigs whose pistons are given simple reciprocating motion by means of eccentrics located above, as shown in Figs. 5 and 6. They are used with sized or classified coal and the jig used for the large sizes and shown in Fig. 5 is radically different from that used for small sizes and shown in Fig. 6.

The Luhrig nut coal jig (Fig. 5) consists of a rectangular box with hopper bottom having a partition in the middle, extending about half way down from the top, or to a point slightly above where the hoppering begins. Upon one side of this partition, is a relatively close-fitting rectangular piston actuated by an eccentric.

Upon the other side of the partition there is a fixed screen slightly inclined away from the partition. The jig is filled with water, to which the piston imparts a pulsating motion, forcing it up and down through

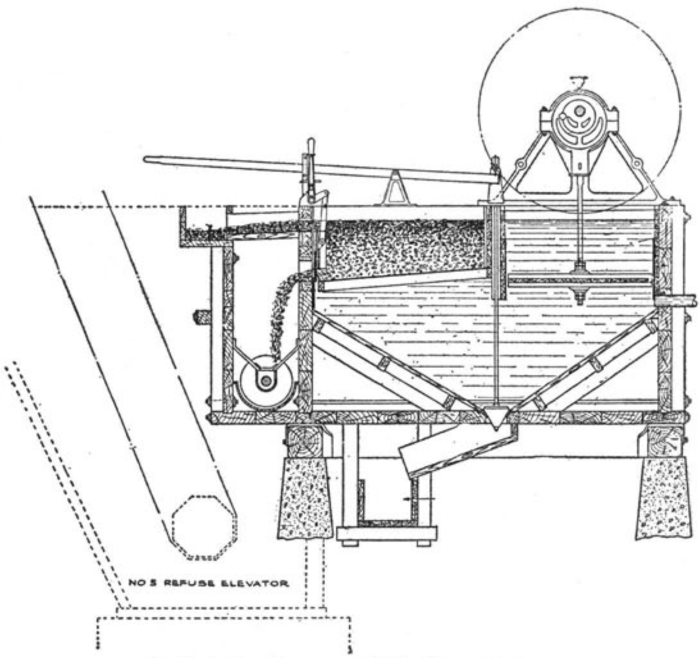


FIG. 5. LUHRIG NUT COAL JIG.

the screen. Sized raw nut coal is fed upon the screen near the partition and purified by the hindered settling action induced by the pulsation of the water through the screen. The washed coal flows from the top of the screen compartment at the opposite end from the feed, while the refuse works its way across, assisted by the slope of the screen, and the excess over that required to maintain a suitable bed is discharged through a valve just above the screen and below the washed coal overflow. The bed is kept thin enough to permit regular and even pulsations of water through the screen, and thick enough to prevent fine coal from working through the screen by the aid of suction and entering the hoppered bottom, or hutch, of the jig. The refuse which collects in the hutch is discharged at intervals, as required, through a valve at the bottom.

The Luhrig fine coal jig (Fig. 6) differs from the nut coal jig in three important particulars. The screen slopes toward the partition, an artificial bed of feldspar is provided, and all the refuse passes through the bed and screen into the hutch from which it discharges continuously. It is fed with fine coal which has been classified in a grading box. The reversal in slope of the screen is for the purpose of bringing the thickest portion of the bed near the piston where the rising current of water is strongest, thus equalizing the pulsations throughout the

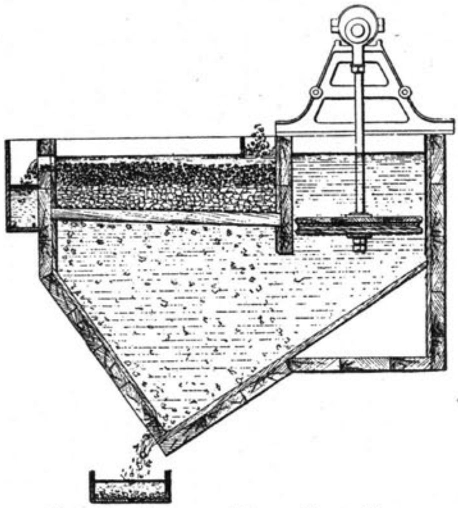


FIG. 6. LUHRIG FINE COAL JIG.

bed. The object of using a false bed is to overcome the tendency which exists in a bed of fine refuse to pack tightly and offer too much resistance to the passage of the water.

Luhrig jigs are the commonest type of piston jigs in use in Illinois, being employed in six washeries. They have screens ranging in size from 33 in. x 35 in. to 42 in. x 54 in. and treat on the average 7.2 tons raw coal per jig per hour. The proportion of nut coal to fine coal jigs is as 5 is to 4. The number of piston strokes per minute in the case of the nut coal jigs averages 79 and the length of stroke varies from 7 in. to 3 in., while the fine coal jigs make an average of 157 strokes per minute with lengths from 2 in. to ¾ in. The size of perforations in the screens of the nut coal jigs varies from ¼ in. to ¾ in., while in the fine coal jigs they are usually ¾ in. or larger, to permit of easy passage of the refuse through the artificial bed of feldspar, though in one washer there is a range of from ⅜ in. to 1⅛ in. in size of opening. Further details may be obtained through an examination of Table 7.

33. *Forrester Jig.*—The Forrester jig (Fig. 7) differs from all other piston jigs in that it is intended for use upon unsized and unclassified screenings. It differs from the Luhrig nut coal jig in three important particulars: It has a level screen, a different method of actuating its piston, and a different manner of disposing of its refuse. Reciprocating motion is imparted to the piston by means of pitmans attached to disc wheels set on a shaft behind and below the jig. This arrangement produces a very compact machine which takes up but little height. The refuse elevator raises the refuse into full view of the operator and thus keeps him in constant touch with the work the jig is doing.

TABLE 7.

LUHRIG JIG PRACTICE.

Washery		All Jigs		Nut Coal Jigs														Fine Coal Jigs		
						No. 1 Extra Jigs			No. 1 Jigs			No. 2 Jigs			No. 3 Jigs					
No.	Rated Capacity per h.	No.	Av. Capacity Tons per h.	No.	Strokes per Minute	No.	Size Treated (inches)	Length of Stroke (in.)	No.	Size Treated (inches)	Length of Stroke (in.)	No.	Size Treated (inches)	Length of Stroke (inches)	No.	Size Treated (inches)	Length of Stroke (inches)	No.	No. of Strokes	Length of Stroke (in.)
19	120	20	6.0	10	72				4	3 - 1¾	5	3	1¾—1	5	3	1—¾	4½	10*	138	2
24	100	13	7.7	7	80				2	3 —1¾	6	3	1¾—1	4½	2	1—¾	3	6	174	2
28	60	11	5.5	7	80				2	3 —2	5½	3	2 —1	4½	2	1—¾	3½	4	150	2½—2
29	125	25	5.0	13	76				4	3 —1¾	5½	5	1¾—1	4½	4	1—¾	3½	12	128	1½— ¾
32	125	15	8.3	9	88	3	3½—2¾	7	3	2¾—1¾	6	3	1¾—¾	4				6	192	2 —1½
34	200	20	10.0	12	80	2	3½—3	6	4	3 —1¾	6	4	1¾—1	5	2	1—¾	4	8	160	1½— ¾
Sum	730	104																		
Av.	122	17	7.2	10	79			6½			5½			4½			3½	8	157	1

* Classified ¾ inches

There is but one Forrester washery now operating in Illinois. At this washery the original Forrester jig design has been modified to the extent of replacing the scraper elevator formerly used by a screw elevator which is said to give much better satisfaction. The jig screen is 30 in. by 36 in. and is perforated with 7/16 in. round holes and the jig has a rated capacity of 25 tons of 2½ in. screenings per hour. The piston makes 6 in. strokes at the rate of 40 per minute.

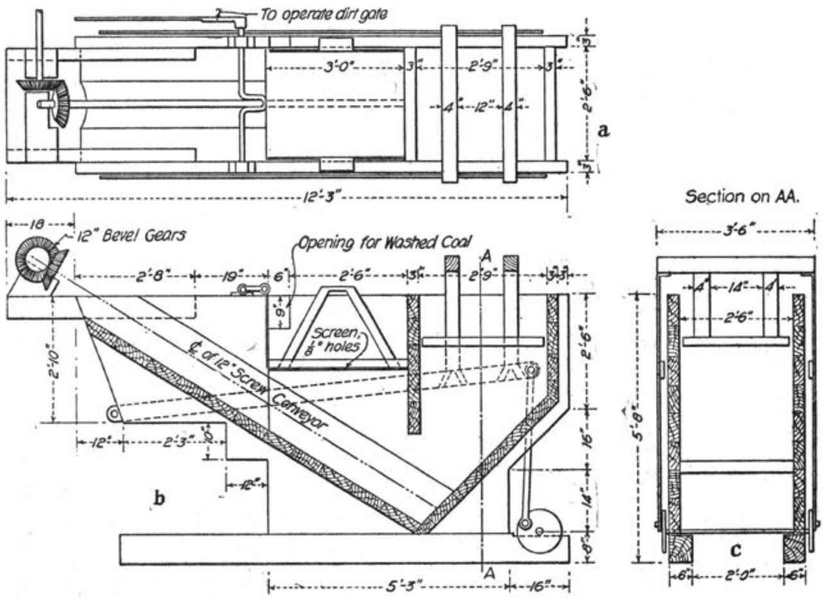


FIG. 7. FORRESTER JIG.

34. *New Century Jig.*—The term "New Century" is applied to all the jigs manufactured by the American Concentrator Company, including some eight or ten adapted to washing coal. In general, these jigs bear a resemblance to the Luhrig nut coal jig. Their principal differences from the Luhrig jig consist in the employment of some form of mechanism to cause the piston to move downwards with greater velocity than it ascends, thus increasing pulsion and decreasing suction; and in the use of a second compartment, or second jig, by which there is obtained not only washed coal and refuse but also an intermediate product called "secondary coal" that may be used about the washery or mixed with the first grade washed coal, as determined by circumstances. Specially designed refuse valves are also used on these jigs. A double New Century jig No. 900, shown in Fig. 8, has a cam and spring to give the desired differential movement to the piston.

TABLE 8.

Tests with New Century Jigs on Illinois Coals.

Locality		Size Tested	Raw Coal		Washed Coal			Second Grade Coal			Refuse		
Town	County	(Inches)	Ash	S	Ash	S	Proportion	Ash	S	Proportion	Ash	S	Proportion
Westville	Vermilion	¾—½ & ½—0*	14.45	3.23	6.50	1.76	72.2	12.06	2.47	19.5	47.81	5.76	8.3
Benton	Franklin	"	13.50	2.48	8.20	2.31	80.6	12.50	2.45	12.2	32.48	9.62	7.2
"	"	"	13.20	2.02	7.00	1.37	82.5	16.00	1.84	12.2	37.00	6.80	6.3
Rend	"	"	11.48	2.65	7.25	1.97	75.0	12.73	2.67	18.7	44.82	9.32	6.3
"	"	"	16.45	1.39	6.45	1.01	84.7	15.60	1.57	7.5	34.00	4.12	7.8
Christopher	"	"	10.40	1.23	6.85	0.95	87.4	17.52	1.89	5.0	46.80	2.89	7.6
"	"	"	12.36	5.11	7.40	2.56	79.9	13.26	3.05	9.0	57.00	16.67	11.1
Royalton	"	¾—⅜ & ⅜—0*	11.57	1.61	6.53	1.01	83.4	18.04	2.32	10.3	25.50	3.12	6.3
West Frankfort	"	⅜—0	11.00	3.00	7.50	1.30	84.0	34.00	8.00	9.7	57.00	18.20	6.3
Herrin	Williamson	¾—½ & ½—0*	9.10	2.04	8.00	1.89	78.4	11.40	4.71	12.3	35.50	11.39	9.3
"	"	"	12.70	2.22	8.50	1.80		16.90	4.31		48.18	12.02	
Harrisburg	Saline	⅜—0	11.22	2.27	6.80	1.55	85.5	37.41		9.6			4.9

*Sizes washed separately and then combined for weighing and analysis.

Tests with New Century jigs on Illinois coals were being conducted at two experimental washeries during the summer of 1912. One of these washeries used a No. 600 jig. It was found that this had a capacity of three tons per hour on 3/8 in. coal and that it worked best with 120 strokes of 5/8 in. per minute. One hundred seventy-five gallons of water per minute were consumed. The jig had a 1/8 in. screen and was operated with natural bed, a pebble bed having been tried first and found unsatisfactory because of the tendency of the rounded pebbles to choke the screen. The other washery employed New Century jigs Nos. 800 and 900, and washed the coal in two sizes. Some of the results obtained at these washeries have been kindly supplied by the operators and are given in Table 8.

35. *Foust Jig.*—The Foust jig (Figs. 9 and 10) is a compartment jig having several screens, each slightly lower than the preceding one, and each supplied with pulsating currents of water by a pair of pistons, one on either side. Like the Luhrig fine coal jig, it is intended for use on the smaller sizes of coal only, but in the case of the Foust jig the

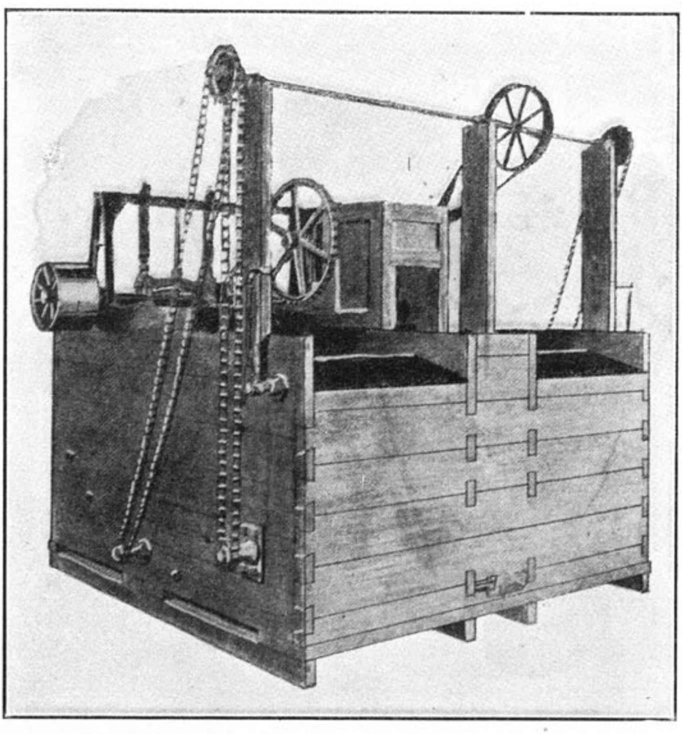


FIG. 8. DOUBLE NEW CENTURY JIG NO. 900.

coal is not classified prior to washing and the jig is not supplied with an artificial bed but makes its own from the refuse in the raw coal. The finer refuse passes through the screen into the hutch while the coarse refuse in excess of that required for a suitable bed is removed through valves in the screens. Only one Illinois washery had a Foust jig in operation in 1912 although two more have put them into commission since then. At the operating washery a two-compartment Foust jig was treating raw coal ¾ in.—0 in size. The pistons were making 130 strokes per minute, the stroke on the first compartment being 1 in. and on the second ⅞ in. The refuse was very clean, containing 74.13 per cent ash (Sample 89).

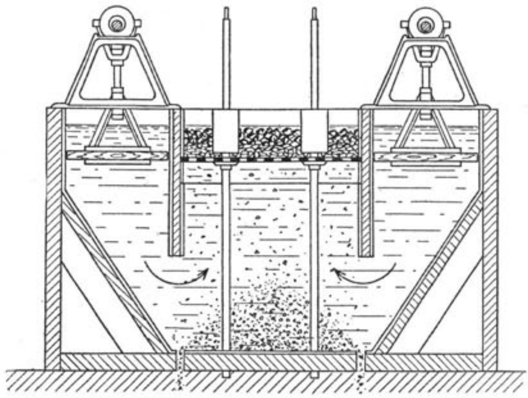


FIG. 9. FOUST JIG, CROSS SECTION.

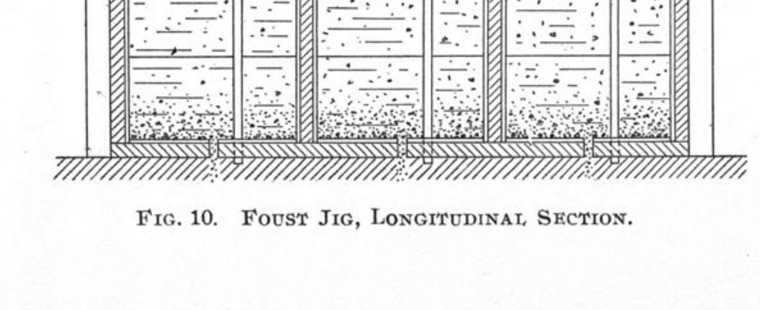


FIG. 10. FOUST JIG, LONGITUDINAL SECTION.

D. PAN JIGS.

The pan jig is the commonest class of washer in use in Illinois. Three types are in operation: the Stewart, the American and the Shannon.

36. *Stewart Jig.*—The characteristic feature of all pan jigs is the box, or pan, with perforated bottom upon which the coal is washed. A view of the pan of the Stewart jig looked at from above is shown in Fig. 11, and a sectional view of the entire jig is given in Fig. 12. Raw

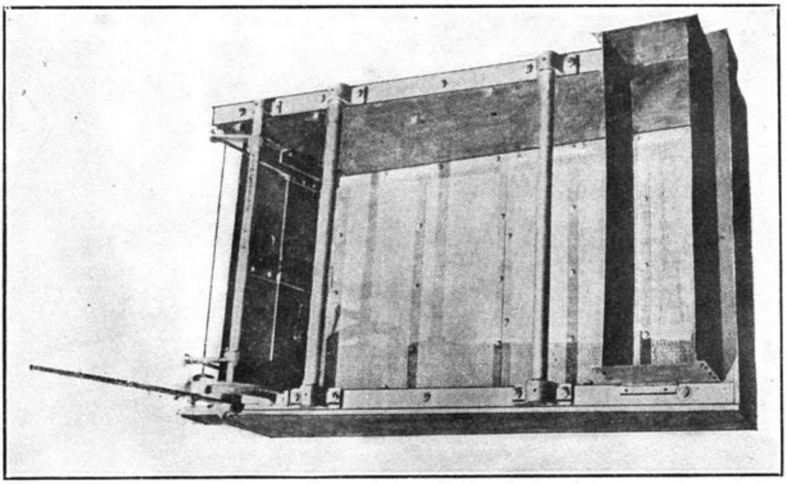


FIG. 11. PAN OF STEWART JIG.

screenings, commonly unsized, are fed into the hopper at one end of the pan, which is held in a jig box filled with water by supports attached to eccentrics located above the pan. These eccentrics give the pan a reciprocating motion and cause the water to rise and fall through the screen in the bottom of the pan, thus producing hindered settling conditions. The coal rises and the refuse sinks and both work their way across the pan, the movement of the refuse being assisted by the inclination of the screen. At the forward end of the pan the washed coal overflows into a launder and the refuse is discharged through an adjustable gate into the hutch where it mixes with the fine refuse which has passed through the pan screen. The mixed refuse is removed continuously by means of a bucket elevator. The water supply comes from a tank back of the pan compartment and connected with it by means of an opening in the hutch beneath the pan. This opening is fitted with a clap valve so arranged as to open by suction when the pan is raised, thus

TABLE 9.

STEWART JIG PRACTICE.

Washery No.	Rated Tons per Hour	No. of Jigs	Tons per Jig per Hour	Width of Jig Pan (feet)	Tons per Foot of Width per Hour	Size of Feed (inches)	Length of Stroke (inches)	Strokes per Minute	Centrifugal Pumps Returning Water (number)
1	50	2	25	4	6	1⅛—0	6	40	8
2	125	1 3	31	4	8	1⅛—¾ sq. ¾ sq.—0	4	40	10
8	60	2	30	5	6	2 x 3½ ell.—0	4	34	(No pump. Water returns by gravity.)
9	100	2	50	6	8	3—0	4	38	8
12	150	4	37½	4	9	3—0	4	36	12
13	100	2	50	6	8	3—0	4	35	9
14	120	4	30	4½	7	3½—0	4	34	10
16	90	4	22½	4½	5	3—0	4	42	8
21	80	2	40	4	10	2—0	4	36	8
26	75	2	37½	5	7½	2½—0	4	40	8
27	60	2	30	3½	9	3—0	3½	32	8
31	160	4	40	4	10	3—0	4	40	10
Sum	1170	34							
Average	97½	3	34	4½	7½		4	37	

allowing water to flow into the hutch and reducing the amount of suction in the jig bed, and to close when the pan is lowered, thus forcing water through the bed with strong pulsion.

The Stewart jig is the commonest type of pan jig in use in Illinois, and is employed in more washeries than is any other type of washing machine. Details of Stewart jig practice at twelve washeries are shown in Table 9. The pan of the Stewart jig is always made 7 ft. in length but its width varies from 3½ ft. to 6 ft. The tons of raw coal per hour based on the rated capacity treated per foot of width of Stewart pan varies from 5 to 10 with an average of 7½. The number of strokes

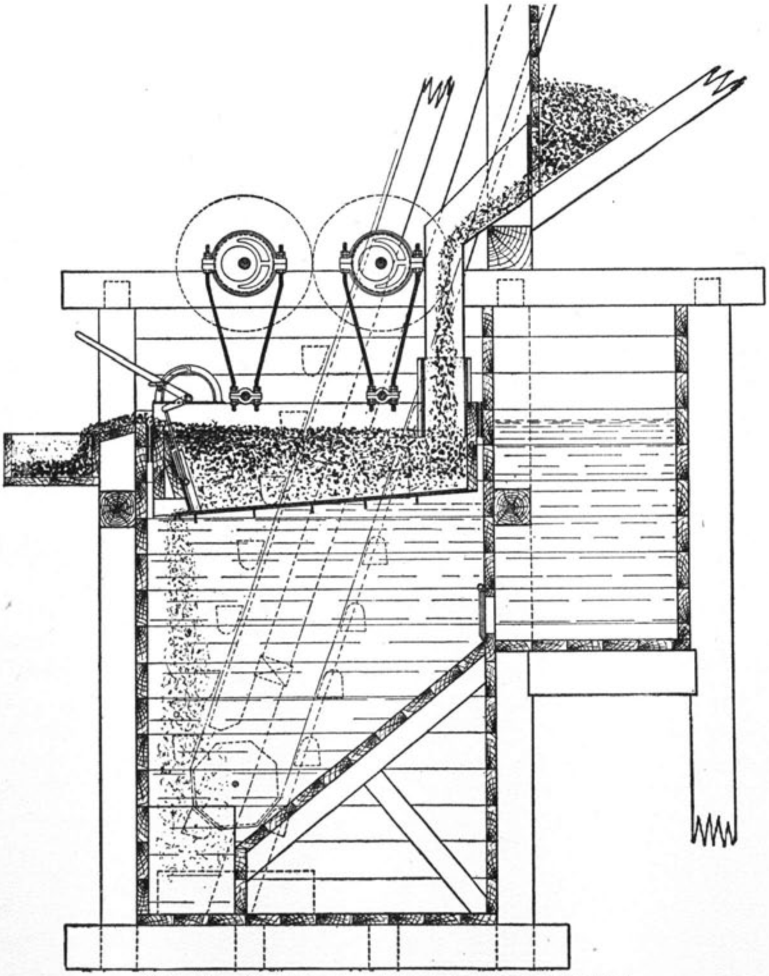


FIG. 12. SECTIONAL VIEW OF STEWART JIG.

made by the pan per minute varies from 32 to 48 with an average of 37, and the length of the stroke is usually 4 in., although in one case it is 3½ in., and in another 6 in. Thus the average Stewart jig treats 34 tons of raw coal per hour in a pan 4½ ft. x 7 ft. in size, which makes 37 strokes 4 in. in length per minute. In some instances, the feed hopper at the end of the jig is omitted, and in others a spray is added at this point to assist in wetting the raw coal as it falls into the pan. The perforations in the pan bottom are round holes of from ¼ in. to ⅜ in. in diameter. Various devices are employed to hold the slate valve open to the desired extent, such as a screw turned by a hand wheel and a pin on the lever fitting into any one of a series of holes in a swinging arm hung in the proper position.

37. *American Jig.*—The American jig, made by the American Coal Washer Company and shown in section in Fig. 13, differs from the Stewart jig mainly in the method of supplying water and in the operation of the refuse valve. While the returning water enters the hutch through a clap valve as in the Stewart jig, its movement through the valve is not dependent upon the suction produced by the rising pan aided by a slight difference in level of water in supply tank and jig box, as in the Stewart jig, but is the result of delivering the water directly to the clap valve by means of a large distributing pipe from a pump having a capacity slightly larger than actually required to fill the jig tank on the up stroke of the pan, thus reducing suction to a minimum. The refuse valve is designed to operate automatically, being opened at intervals as desired, but always to its fullest extent, thus preventing the accumulation and jamming of large pieces of shale in front of the gate. A safety device is provided which keeps the refuse valve in operation as long as raw coal is supplied to the jig, but disconnects it automatically when the feed ceases.

American jigs are used in five Illinois washeries. In the majority of these, the refuse valve just described has been discarded in favor of a simpler discharge like that employed on the Stewart jig. Details of American jig practice are shown in Table 10. From this it is apparent that the average American jig has a pan 4 ft. in width and treats 37 tons per hour, using 4 in. strokes at the rate of 41 per minute. Comparing this average with that for the Stewart jig as shown in Table 9, it is found that the American jig is rated as having 20 per cent greater capacity than the Stewart. At one American washery the coal is sized on a woven wire screen with 9/16 in. openings before washing.

38. *Shannon Jig.*—The Shannon jig (Fig. 14) does not attempt to force the water through the coal in the pan by making it fit the pan compartment snugly, but obtains a similar effect by prolonging the sides of the pan downwards below the screen and using comparatively rapid strokes. The pan is held free from the walls of the pan compartment by

TABLE 10.

AMERICAN JIG PRACTICE.

Washery No.	Rated Tons per Hour	No. of Jigs	Tons per Jig per Hour	Width of Jig Pan (feet)	Tons per Foot of Width per Hour	Size of Feed (inches)	Length of Stroke (inches)	Strokes per Minute (number)	Centrifugal Pump Returning Water (number)
4	100	2	50	4	12½	1½—0	4	48	8
15	80	2	40	4	10	3½—0	4	34	8
17	280	8	35	4	9	1¼—0	4	36	2—No. 10s
18	140	4	35	4	9	3 —0	4	36	10
20	140	2 2	35	4	9	3—9-16 sq 9-16 sq—0	4	48	10
22	140	1 3	35	3½ 4	9	3 —0	4	45	10
Sum Average	880 176	24 5	37	4	9		4	41	

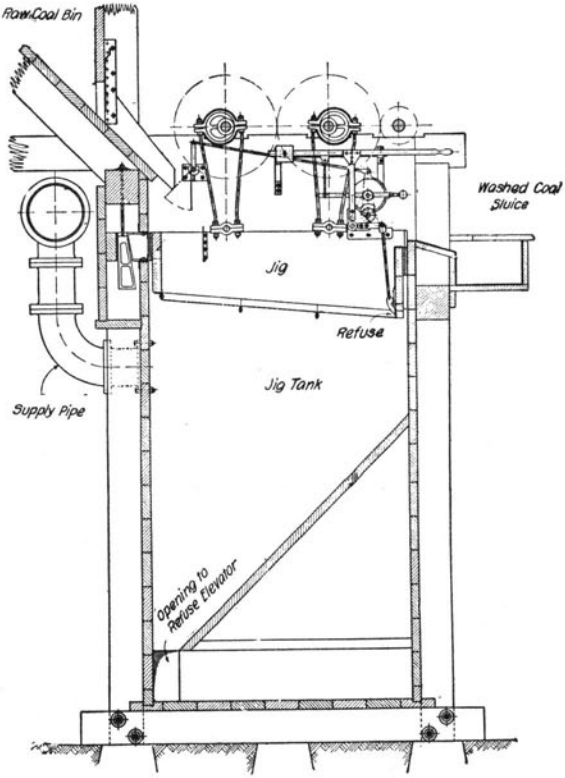


FIG. 13. SECTIONAL VIEW OF AMERICAN JIG.

means of rollers. Another peculiarity of the Shannon jig is that the washed coal compartment and pan compartment are connected at the top so that water is free to move back and forth between them, which greatly reduces the quantity of water which must be pumped to keep the jig going.

Three washeries employing Shannon jigs were in operation in Illinois in 1912. The jigs were all 4 ft. x 6 ft. in size and were rated to treat from 40 to 62½ tons raw coal per hour with an average of 47 tons. This is 25 per cent in excess of the average rating for a 4 ft. x 7 ft. American jig and 50 per cent in excess of that for a 4 ft. x 7 ft. Stewart. The number of strokes of the pan per minute varies from 72 to 90, which is about twice the number used on Stewart and American jigs, while the length of stroke is from 3 in. to 3½ in., which is less than for other pan jigs. At one washery the Shannon jigs are treating coal sized between 3 in. and ¾ in., the smaller size going to a Foust jig, while the other two are working on unsized screenings. The new water required by each jig is supplied through a small pipe near the raw coal feed. At one washery the pipe at each jig was a 2½ in. pipe hammered flat so as to leave a ⅜ in. slot through which water was delivered under 30 pounds pressure.

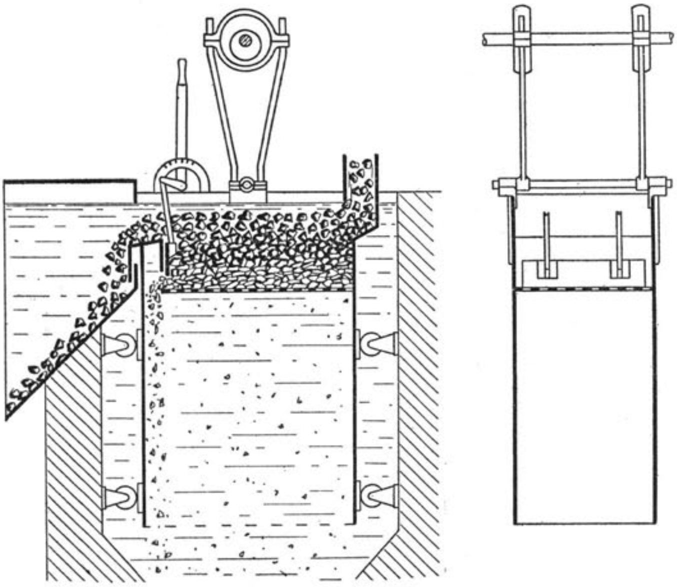


FIG. 14. SHANNON JIG.

E. BUMPING TABLES.

39. *Campbell Table.*—Campbell bumping tables are employed at one operating Illinois washery. Each table is 2½ ft. in width by 7½ ft. in length, with a working deck of sheet iron corrugated transversely and having a variable slope which is 5 degrees steeper at the back than at the front. It has sides of board and a wooden keel running lengthwise with a steel-shod bumper at the back end, the whole suspended by rods from above and provided with means of regulating slope and length of swing. The table is shown in Fig. 15. Swinging motion is produced by means of a cam of peculiar oval form working in conjunction with a rocker and rocker arm, arranged to give a slow forward motion and quick return, with velocity gradually increasing up to the moment of impact with the bumping block on the framework back of the table. The feed is delivered upon the center of the table, the refuse being jerked and bumped backward and upward until it falls over the back of the table and the coal washed downward and forward until it flows off the front.

The washery is rated at 40 tons per hour and contains seven tables,

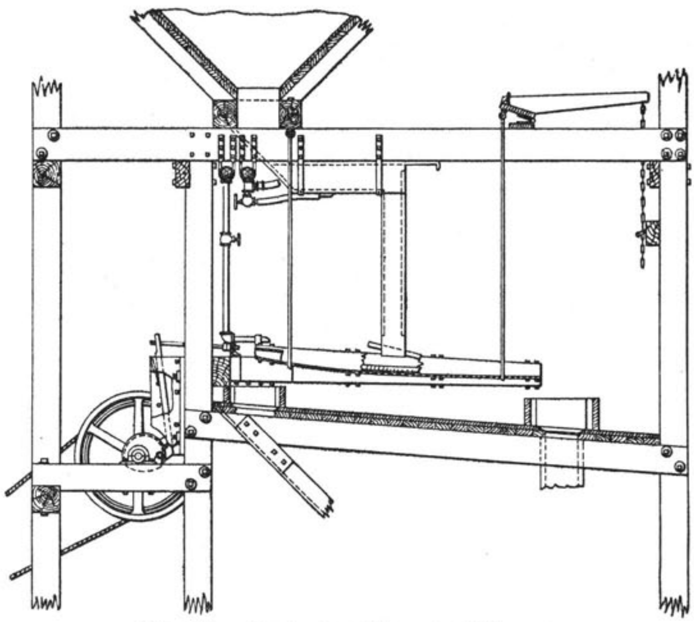


FIG. 15. CAMPBELL BUMPING TABLE.

three working on 3¾ in. —1¾ in. raw coal, three on 1¾ in. —⅜ in., and one on ⅜ in. —0. The slope is varied to suit the size, character and quantity of feed. The tables treating medium sized coal had a slope of 7 degrees in front and 12 degrees in the rear. The tables receive 76 bumps per minute, the stroke being 5 in. for the coarse, 2½ in. for the medium, and 1¼ in. for the fine coal.

VII. SIZING WASHED COAL.

The sizing of raw coal and general considerations connected with sizing have already been discussed in Chapter V. There are two reasons for sizing washed coal: to improve its appearance and to improve its burning qualities. Considerable breakage occurs during the process of washing, so in order to produce a well-sized product it is necessary to size after washing, even if the coal has been given a preliminary sizing prior to washing.

40. *Sizes and Trade Names.*—At the time the writer visited the Illinois washeries, all save one were making more than one size of washed coal, and that one had already installed a screen for making a second size. The number of sizes made varied from 2 to 7, the number being smaller, as a rule, in the Northern field than in the Central or Southern, as will be seen by reference to Table 11. Where two sizes are made

they are designated "washed nut" and "washed slack," and where more than two, they are designated by number, as shown in the table. But while a number of washeries are shipping washed coals under the same designation, curiously enough there are no two washeries making washed coals of exactly the same sizes. The range is as follows:

	No. 1 Extra	No. 1	No. 2 Extra	No. 2	No. 3	No. 4	No. 5
			INCHES				
Always under	3¾	3½	2¼	2¼	1½	⅞	$\frac{7}{16}$
Always over	2½	1¾	1⅜	⅞	⅝	$\frac{3}{16}$	0

The ranges are thus seen to overlap widely, and there is wide variation within the ranges, so that the No. 1 washed coal of one producer may correspond with the No. 2 of another, and the No. 2 produced at one washery with the No. 3 at another. The consumer buying washed coal by name or number is therefore unable to tell what size he will actually obtain except from previous experience or from a knowledge of the sizes of screens employed in the washery whence the coal comes. It is evidently desirable from the point of view of the purchaser, at least, that a standard set of sizes be adopted. In 1903, the operators of Williamson County agreed to the following standard sizes:*

Designation	Through	Over
No. 1	3 in. round holes	1¾ in. round holes
No. 2	1¾ in. round holes	1 in. round holes
No. 3	1 in. round holes	¾ in. round holes
No. 4	¾ in. round holes	¼ in. round holes
No. 5	¼ in. round holes	

This agreement has not been adhered to, however, and the sizing of washed coal throughout Illinois is badly in need of standardization. It has been pointed out in Chapter V that in order to produce sizes the particles in each of which shall have the same variation in diameter, the openings in the washery screens must have a constant geometrical ratio. The advantages of adopting such a screen scale would be that each size, with the exception of the smallest, would be sized to exactly the same degree, and the series of sizes would therefore present the best possible appearance. It has already been shown that such a screen scale would be of advantage in the preliminary sizing prior to washing. For these reasons, the writer suggests the adoption of the following standard sizes for washed coals:

Designation	Through	Over
No. 1	4 in. round holes	2 in. round holes
No. 2	2 in. round holes	1 in. round holes
No. 3	1 in. round holes	½ in. round holes
No. 4	½ in. round holes	¼ in. round holes
No. 5	¼ in. round holes	

*McGovney, C. S. "Tests of Washed Grades of Illinois Coal." U. of I. Eng. Exp. Sta Bull. 39.

TABLE 11.

SIZES AND TRADE NAMES OF ILLINOIS WASHED COALS.

Washery No.	No. of Sizes	Diameter in Inches (Round holes unless otherwise noted) "Nut"	"Slack"	"No 1 Extra"	"No. 1"	"No. 2 Extra"	"No. 2"	"No. 3"	"No. 4"	"No. 5"
Northern Field										
1	2	1⅛—¾ sq.	¾ sq ⅛							
2	2	1¼—¾ sq.	¾ sq - 3/16							
3	1		⅞ bar—3/32 & 1/16							
4	3				1½—1⅜ sq		1⅜ sq—⅞ sq	⅞ sq—3/32		
5	2	2½—2	2-0							
6	2	2¼ & 2½—1¼	1¼—1/16							
7	2	1½ bar—1¼	1¼—1/16							
8	5				2x3½ ell—1¾		1¾—1¼	1¼—¾	¾—⅜	⅜—0
9	5				3—2¼		2¼—1½	1½—¾	¾—5/16	5/16—1/16
*10	2	¾—⅜	⅜—0							
*11	1		⅜—0							
Central Field										
12	5				3—1¾		1¾—1¼	1¼—¾	¾—5/16	5/16—1/16
13	7			3½—2⅞	2⅞—2¼	2¼—1¾	1¾—1¼	1¼—¾	¾—5/16	5/16—0
14	5				3½—1¾ sq		1¾ sq—1sq & 1⅜	1 sq & 1⅜—⅞	⅞—¼	¼—0
15	5				3½—2¼		2¼—1¼	1¼—⅞	⅞—⅜	⅜—0
16	5				3—1⅞		1⅞ 1¼	1¼—⅞	⅞—5/16 & ¼	5/16 & ¼—0
17	3							1¼—11/16	11/16—⅜	⅜—0
18	5				3—1¾		1¾—1⅛	1⅛—¾	¾—¼	¼—0
19	5				3—1¾		1¾—1	1—¾ & ½	¾ & ½—¼	¼—0
20	5				3—1¾		1¾—1⅛	1⅛—¾	¾—¼	¼—1/16
21	5				2 & 1¼—1½		1½—1	1—⅜	⅜—¼	¼—3/16
22	5				3—1¾		1¾—1⅛	1⅛—¾	¾—⅜	⅜—1/16
23	5				3—1¾		1¾—1¼	1¼—¾	¾—⅜	⅜—0
24	5				3—1¾		1¾—1	1—¾	¾—¼	¼—0
25	5				3—2		2—1⅛	1⅛—11/16	11/16—¼	¼—1/16
Southern Field										
26	4				2½—2		2—1¼	1¼—1		¼—0
27	4		¾—⅛		3—2		2—1	1 ¾		
28	5				3—2		2—1	1—¾	¾—¼	¼—0
29	6			3—2¾	2¾—1¾		1¾—1	1—⅝	⅝—⅜ & 3/16	⅜ & 3/16—0
30	6			3¾—3	3—1¾		1¾—1	1—¾	¾—¼	¼—0
31	5				3 1¾		1¾—1¼	1¼—¾	¾—7/16 & ⅜	7/16 & ⅜—0
32	6			3½—2¾ & 2½	2¾ & 2½—1¾	1¾—1⅜	1⅜—⅞		⅞—⅜	⅜—3/16
33	5				3½—1¾		1¾—1	1—¾	¾—5/16 & ¼ & ½ sq	5/16 & ¼ & ½ sq—0
34	7			3½—3	3—2¼	2¼—1¾	1¾—1 3/16	1 3/16—¾	¾—5/16	5/16—3/16
35	5				3—2		2—1	1—¾	¾ ¼	¼—0

* Experimental

In the proposed screen scale—¼ in., ½ in., 1 in., 2 in., 4 in.—the ratio employed is 2. The scale begins with ¼ in., the size most commonly used for making No. 5 coal, and ends with 4 in., which is ¼ in. larger than the largest size at present washed. If it were desired to make more than five sizes, the suggested sizes might be subdivided on the ratio $\sqrt{2}$, the larger particles being designated by the number and the affix "extra," and the smaller particles by the number and the affix "small." Carried to eighths of an inch, these sizes would be as follows:

Designation	Through	Over
No. 1 Extra	4 in. round holes	2⅞ in. round holes
No. 1 Small	2⅞ in. round holes	2 in. round holes
No. 2 Extra	2 in. round holes	1⅜ in. round holes
No. 2 Small	1⅜ in. round holes	1 in. round holes
No. 3 Extra	1 in. round holes	¾ in. round holes
No. 3 Small	¾ in. round holes	½ in. round holes
No. 4 Extra	½ in. round holes	⅜ in. round holes
No. 4 Small	⅜ in. round holes	¼ in. round holes
No. 5 Extra	¼ in. round holes	⅛ in. round holes
No. 5 Small......	⅛ in. round holes	

Gravity screens, drag screens, revolving screens and shaking screens are all employed to size washed coal in Illinois washeries, as will be seen by referring to Appendix E. Gravity screens are installed in chute bottoms and used only to relieve or supplement other types of screens. Drag screens are occasionally employed for general sizing but most frequently for rinsing fine coal, drag rinsing screens being in use in seven Illinois washeries.

Shaking screens are in use for general sizing of washed coal, especially in washeries where the coal has not been sized as a preliminary to washing. They are employed in three washeries for resizing washed coal, the average screen having a slope of 10½ degrees, making 155 strokes 4½ in. in length per minute, and having 1.35 sq. ft. screen surface per ton of coal per hour. For the fifteen washeries employing shaking screens for sizing washed coal not previously sized raw, the average, in so far as figures are available, is as follows: slope, 9 degrees, strokes, 138 of 5 in.; square feet of surface per ton per hour, 1.7. The figures 1.35 and 1.7 are unfortunately not comparable, 1.35 being an average for two screens only and 1.7 being reduced to 1.4 if a single exceptional screen is omitted. We have seen that 0.7 sq. ft. per ton dry coal per hour is the average bituminous practice. Wet coal requires more screening area, and the Illinois shaking screens conform to this requirement by having twice that area.

Revolving screens are used in Illinois for the general sizing of washed coal, and particularly for the resizing of coal which has been previously sized raw. As in the case of raw coal screens, their peripheral speed averages above 200 feet per minute and below 250 feet, which is desirable, but in many cases it greatly exceeds the 250 feet per minute which is set by some writers as the maximum permissible speed. The average square feet screen area per ton per hour for raw coal revolving screens was found to be 4.2. Wet revolving screens should have larger proportional areas, and the averages 5.66 and 6.5 sq. ft. for resizing and sizing screens, respectively, appear on their face to show that this requirement is carried out. A closer inspection, however, demonstrates that this is not the case with the sizing screens, the figure 6.5 being lowered to 3.4 if a single exceptional screen be omitted from the average. Illinois washed coal revolving screens, like the raw coal revolving screens, appear to be smaller on the average than required by good practice in other parts of the United States.

The proportions of different sizes produced by most of the operating washeries are shown in Table 12. The sizes to which these proportions refer are indicated in Table 11. About one-sixth of the washed coal produced at the two-size washeries of northern Illinois makes nut coal and the other five-sixths makes slack. Five numbered sizes are commonly made in central and southern Illinois. On the average, more No. 4 is produced than any other size, No. 5 being next in the Central field, and No. 2, with No. 1 a close second, in the Southern field. In other words, the Central coal field produces larger proportions of the smaller sizes of coal than does the Southern.

VIII. Hand Picking.

Hand picking is used in conjunction with washing to remove, first, lumps of refuse which have remained with the coal as a result of imperfect washing, and, second, lumps which could not be removed by washing, but which contain numerous thin flakes of pyrite that while not materially increasing its specific gravity, ash or sulphur contents, detract from its appearance.

Only one Illinois washery employs a man regularly and solely to pick bad pieces from its washed coal. In this washery the largest two sizes are passed over an apron conveyor and from this the picker removes about 1½ tons of refuse per day. The hand-picked refuse contains 69.16 per cent dry ash and 3.54 per cent dry sulphur, as shown by Analysis 55, Appendix D. At two washeries there are men who employ part of their time picking refuse from the washed coal as it leaves the resizing revolving screens, and at one washery bad lumps are thrown out of the larger sizes as they are being loaded into the cars.

TABLE 12.

PERCENTAGES OF WASHED COALS PRODUCED AT ILLINOIS WASHERIES.

Field	Washery No.	Nut	Slack	No. 1 Extra	No. 1	No. 2 Extra	No. 2	No. 3	No. 4	No. 5
Northern	1	10.00	90.00							
	2	10.67	89.33							
	3		100 00		2 44		21.98	75.58		
	4									
	5	21.30	78.70							
	6	20 00	80.00							
	7	20.00	80.00							
	8				8.00		12.00	23.00	57.00	
	9				3.10		5.90	33.50	25.70	31 80
(a) Average for 5 washeries making 2 Sizes.		16.40	83.60							
Central	15									12.00
	17							60.70		39.30
	18				14.26		18.31	11.82	28.84	26 77
	19				10.12		22.98	23.27	21.72	21.91
	20				17.11		17.74	13 56	28.77	22.82
	21				15.00		18.00	23 00	26 00	18.00
	22				1 24		18.75	19.47	22.53	38.01
	23				17.20		12.30	20 30	32.00	18.20
	24				17.09		17.90	15.10	23.57	26.34
	25				2.80		17.40	21.20	30.30	28.30
(b) Average for 8 washeries making 5 Sizes.					11 85		17.92	18.47	26.72	25.04
Southern..............	27		36.10		16.90		21.60	25.40		
	28				9.80		28.00	8.70	34.20	19.30
	31				23.37		18.09	10.78	22.40	25.36
	32			9.00	15.80	12.40	15 60		27.20	20.00
	33				24 00		21.00	15.00	22 00	18.00
	35				26.80		18.60	18 50	27.90	8.20
(c) Average for 4 washeries making 5 Sizes.					20.99		21.42	13.25	26.62	17.72

IX. Arrangement of Washeries.

Washeries must be arranged to receive raw coal, separate it into washed coal and refuse, and dispose of both these products. They must be supplied with power to run the machinery and water to wash the coal. In the simplest Illinois washery (No. 6), the screenings from the tipple are delivered directly to the washing machine making washed coal and refuse. The washed coal is sized, making "nut" and "slack," which fall into bins whence they are drawn into cars for shipment. The refuse is drawn into a car and trammed to a refuse dump. A single engine supplies the power and a single pump provides fresh water. In a more complicated but not unusual washery (No. 29), the raw screenings from the tipple are delivered to a scraper conveyor which carries them to the top of the washery, where they pass into a raw coal bin. They are next sized and each size delivered to a different set of washing machines which produce washed coal and refuse. Keeping the sizes separate, they are next resized and all but the smallest size fall into bins whence they are drawn into railroad cars. The smallest size is collected in a settling tank and raised by a bucket elevator to its bin. All the refuse is delivered to a single refuse tank whence it is drawn into a car which hauls it up the refuse pile and dumps it there. Not only are there pumps for fresh water but a pump is provided for returning dirty water.

The arrangement of a washery is still further complicated when provision is made for crushing raw coal or for crushing and rewashing refuse. Poor original design and change in method of treatment after erection also have introduced serious complications in several instances.

41. *Receiving Coal.*—All but two of the operating Illinois washeries are situated near a mine from which they are receiving screenings, and might therefore have their raw coal delivered to them by means of some form of conveyor. In several instances, however, this would mean a conveyor of undesirable length, while in others the washery is receiving coal not only from the neighboring mine, but also from a mine or mines at a distance, raw coal being shipped on railroad cars to thirteen washeries. Mechanical car unloaders are employed at twelve of these washeries, but are far from giving satisfaction, because of the large amount of manual labor they entail. Not only must there be a man to operate the unloader and a crew to move cars, but there are required two or more men to shovel back of the conveyor in the car. At the thirteenth washery the raw coal is dumped into a hopper beneath the track, whence it is removed by a scraper conveyor delivering into a bucket elevator, which raises it to the top of the washery. This is a much more satisfactory arrangement when bottom-dumping cars are available.

In one case, the tipple is near enough to the washery so that by omitting the raw coal bin the screenings will run by a chute directly to the washing machine, while in another the coal is trammed by hand from the tipple, but in the majority of cases some form of conveyor or elevator is necessary. There are seven scraper elevators in use conveying raw coal from beneath the tipple screen to the top of the washery, six conveying belts, five bucket elevators and one "Pacific Coast" conveyor, which is a cross between an apron conveyor and a bucket elevator. The belts employed are all of rubber. In one washery where a canvas belt was tried it lasted only one year where a rubber belt lasted five years.

When the coal is to be sized before washing, it passes from the receiving appliance into the raw coal screen from which the different sizes fall into separate bins. When the coal is to be sized after washing only, it usually falls directly into the raw coal bin. In two washeries, however, the coal is weighed on Richardson automatic scales before passing into the bin. From the raw coal bins the coal flows into the washing machines. Revolving pocket feeders are in use at two washeries and a number of the pan jig washeries employ a feeding device, consisting of a sheet iron gate with a rope attached to it and to the jig in such a way that the gate opens and closes with each stroke of the eccentrics. Just as the coal is leaving the bin and before it falls into the washer, it is frequently sprayed to insure its prompt and thorough wetting.

Washing machines and washed coal screens require but a passing mention at this point, having been described in the two chapters preceding. It is well to recall that the fine coal to be washed on Luhrig jigs is mixed with water after passing through the raw coal screen and classified in a grading box, the different products passing to separate Luhrig fine coal jigs arranged in a battery.

For purposes of flexibility, it is highly desirable that good-sized storage bins be provided for both raw and washed coal. A large raw coal bin permits the washery to run during periods when the hoisting of coal at the shaft is interrupted, while large washed coal bins permit it to operate during interruptions in the car service. The majority of Illinois washeries do not appear to be adequately supplied with bins. In the case of 24 washeries, with an average rated tonnage of about 100 tons raw coal per hour, the average raw coal bin is of about 200 tons capacity and the average washed coal storage about 250 tons. It is evident that in the majority of these washeries even a slight interruption in the car supply or raw coal delivery would necessitate a shut-down.

Where the washed coal bins have considerable capacity, coal dropping from the screens will be badly broken unless the bins are nearly filled. In order to prevent this, "telegraphs" are installed in many of the bins, designed to hold the larger sizes of washed coal. The telegraph is simply a chute, or series of chutes, so arranged that the screened coal will slide, instead of falling, into the bin. Telegraphs are in use for the larger sizes of washed coal in eight washeries. A single spiral chute is the most popular form, although in some cases a series of chutes is employed, having each successive member inclined in the opposite direction and arranged in such a manner that the coal drops a short distance from the bottom of one to the top of the next.

The commonest method of disposing of refuse is to haul it up an inclined refuse pile and dump it. This is done at 25 washeries. At four washeries the refuse is trammed by hand to the dump, at three it is sluiced with water, and in one instance all the refuse is loaded into railroad cars for ballast.

The washery water is usually kept in continuous circulation by means of a centrifugal pump, a piston pump or pumps being employed to supply the fresh water needed to replace the water taken up by the washed coal and refuse and lost in other ways. Five washeries, however, use all fresh water, which is desirable if not too expensive, as better results can be secured when washing with clean water.

42. *Settling Tanks.*—There are settling tanks in 27 washeries. In all but three of these the settler is used to collect the No. 5 washed coal, but in three it is used to purify the circulating water and the settlings are added to the refuse from the washing machines. In the majority of the settling tanks there is a slow-moving drag, which forces the settled material toward one end of the tank, whence it is raised by a bucket elevator. If the raw coal contains fireclay the circulating water soon becomes charged with fine particles of clay which remain in suspension only so long as the fluid is in rapid motion. When there is a large quantity of this fine clay in the water, it deposits when the water slows up in the settling tank. For this reason, the settling tanks have recently been removed in two Illinois pan jig washers. The result is that the slowest part of the circulation is in the hutches below the pans and the clay deposits there and is removed with the other hutch refuse. At other washeries, the deposition of fireclay in settling tanks collecting fine coal only becomes troublesome when the machinery slows down or is stopped for the night. In these cases it is customary to run all the settlings into the refuse for a short time after resuming operations. Even under the most favorable conditions the water in time collects an undesirable quantity of clay and pyrite and it is necessary to provide fresh water for the entire system at intervals varying from once a day to once a week.

43. *Construction.*—The construction of a washery has a decided influence upon its arrangement. All but one of the operating Illinois washeries are of wooden construction and present appearances similar to that of washery No. 26, shown in Fig. 16. Contrast this with Fig. 17 showing washery No. 23, which is of steel and concrete construction, noting particularly the large conical storage bin for raw coal and the smaller conical bins for washed coal.

44. *Flow Diagrams.*—Flow diagrams for Howe, Robinson, Luhrig, Forrester, Shannon and Foust, Shannon, Stewart, American, and Campbell washeries will be found in Appendix F.

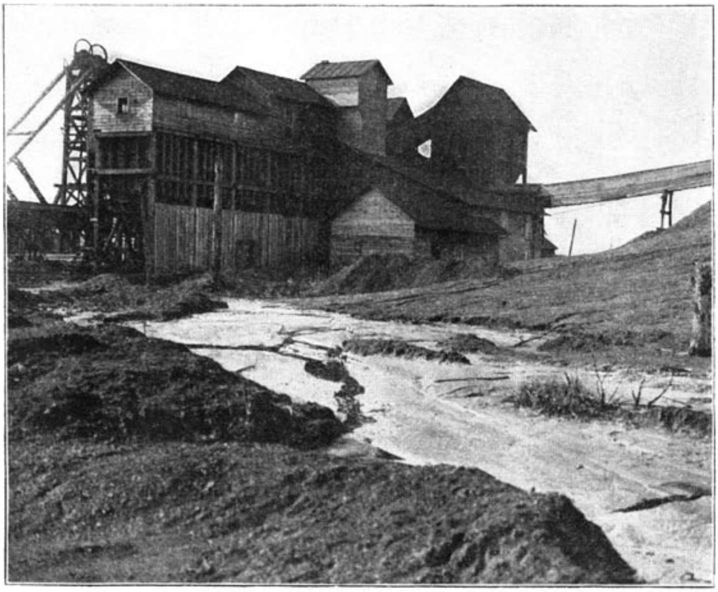


FIG. 16. WASHERY OF THE BIG MUDDY COAL AND IRON COMPANY AT HARRISON, ILL.

FIG. 17. SHANNON WASHERY OF THE SHOAL CREEK COAL COMPANY AT PANAMA, ILL.

X. Results of Washing.

A. General.

The effect produced by washing is usually measured by comparing the ash, sulphur and British thermal unit determinations on the washed coal with those on the raw coal. In the washed coal the percentages of ash and sulphur are lower and the number of British thermal units higher. A fair idea of the general effect of washing as practised in Illinois may be obtained by a consideration of the averages for the ten washeries in Tables 13, 14 and 15.

45. *Ash.*—In Table 13, "Face" designates the samples taken across the working face of the coal bed excluding shale and sulphur partings, which the miner is supposed to remove. Ash determinations on such samples indicate the lowest possible results which could be secured by mining. It will be observed that the coals as actually mined contain about 50 per cent more ash than the face samples, which is due to the inclusion of material from the roof and the floor, and to failure to exclude partings. Thus the average face sample in the table contains 9.60 per cent ash and the mine run 14.58 per cent. The additional 5 per cent ash is mainly in the shape of small impurities, for upon screening there is produced a lump coal which has about the same ash content as the face, and screenings with a little more than twice that amount. When these screenings with their high ash content of 20.81 per cent are treated in the washeries, washed coal with only 9.81 per cent ash are obtained. The average percentage for excess of ash for run of mine coal over face samples, as given by Table 13, has been found to vary quite widely in other analyses made at the University of Illinois. This is to be expected, however, owing to the difficulty of properly sampling run of mine coal, and until a better method of sampling such coal is found no general figure can be determined for the relation between the ash in run of mine and in face samples. The general effect of the process of washing upon the ash contents of the screenings is thus seen to be their reduction to about the same amount as in the face and in the lump coal. It should be noted, however, that while the washed coal as a whole is no better than the lump and face, Nos. 1, 2 and 3 are about 10 per cent better. No. 4 has about the same ash content as the face and lump, while No. 5 is about 30 per cent higher.

46. *Sulphur.*—From Table 14 the sulphur content of the face is seen to be about equal to that of the mine run. This may be explained on the ground that sulphur partings which should be excluded find their way into the coal as mined, but that the extra sulphur thus introduced is diluted with sulphur-free shale from floor, roof and partings and the sulphur content of the mixture is brought down to that of the face. The lump is about 20 per cent better than the face, and the screenings

TABLE 13.

Dry Ash Contents of Illinois Raw and Washed Coals.

Coal Bed	Coal Field	Raw Coal				Washed Coal					
		Face %	Mine Run %	Lump %	Screenings %	Screenings %	No. 1 %	No 2 %	No. 3 %	No 4 %	No. 5 %
2	Northern	8.89	16.95	11.40	28.58	11.06	9.74	11 43			
2	"	7.33	18 91	6.20	29.30	9 05	6.77	4.93	5.13	11.83	
2	"	5.64	10.45	6.80	27.10	6 69	5.86	6.60	6.29	6 85	7.07
6	Central	11 01	13.62	11.72	16.48	10.29	9.61	9.99	10 79	10 29	12.92
6	"	10.51	18.00	10.00	18.43	12.52	10.30	9.70	10.40	10.90	18.31
6	"	12.75	15.15	12.93	25.76	10.83	11.57	6.04	10 60	8 80	14.25
6	Southern	12.43	17.03	10.58	20.51	9.07	5.63	8.88	8 78	7.44	14.14
6	"	7.94	11.73	10.68	12.43	10.08	9.12	9.00	9.28	10 76	11.46
6	"	9.73	11 42	8.35	13.47	9.15	9.09	8.16	8.78	9.46	11.60
6	"	9.80	12.50	7.90	16 00	9.39	7 65	8.41	8.10	8.25	13.45
	Average	9.60	14.58	9.66	20.81	9.81	8.53	8.31	8.96	9.60	12.65

TABLE 14.

Dry Sulphur Contents of Illinois Raw and Washed Coals.

Coal Bed	Coal Field	Raw Coal				Washed Coal					
		Face %	Mine Run %	Lump %	Screenings %	Screenings %	No. 1 %	No. 2 %	No. 3 %	No. 4 %	No. 5 %
2	Northern	3.23	3.38	3.12	3.93	3.76	3.72	3.77			
2	"	3 28	2 84	1.80	3.69	2.98	2 72	2.55	2.78	3.18	
2	"	2.59	2.41	2.30	2 90	2.77	2 64	2.80	2.81	2.78	2.74
6	Central	4.75	3.63	3.18	4.30	3.60	4.05	3.98	3 49	3 33	3.68
6	"	5 23	4.90	4.00	4.70	4.60	4.50	4 40	4.40	4.40	4.77
6	"	5.51	4.73	5.34	5 80	4.16	3.75	3 55	4.14	4.45	4.60
6	Southern	3.51	4.31	2.09	5.51	2 62	2.67	2.45	2.83	2.67	2.68
6	"	1.51	1.69	1.41	1.87	1 47	1.40	1.55	1 52	1.57	1.38
6	"	1.06	2.16	1.49	2.61	2.41	2 60	1.93	2.64	2 31	2.72
6	"	2.35	2.89	2.00	3.11	1.95				1.53	1.77
	Average	3.30	3.29	2.67	3.84	3.03	3.11	2 98	3.12	3.00	3.13

20 per cent worse as far as sulphur is concerned. The washed coal, with an average of 3.03 per cent sulphur, shows an improvement of about 10 per cent over the face and lump with 3.30 per cent and 3.29 per cent; and an improvement of about 20 per cent over the raw screenings with their average of 3.84 per cent sulphur. The slight variations between the sulphur contents of the different sizes of washed coals do not seem to be sufficiently regular to permit of any generalizations.

47. *British Thermal Units.*—In Table 15 another factor has been introduced: coal free from ash and sulphur, the "unit coal" of Parr.* The British thermal units in this substance are obtained by calculation, and indicate the highest heating values that coals could have if all their ash-forming impurities and organic sulphur were removed. The average for unit coal is 14 598 British thermal units, while the face is 13 007, or about 1600 units less. The mine run is about 800 units lower, but just as was the case with the ash, the lump contains approximately the same number of British thermal units as the face. The average for raw screenings is 11 166, or about 1900 units less than the face and lump, while for washed screenings it is 12 959, or nearly the same as the face and lump and thus again similar to the ash content. This similarity extends also to the individual sizes of washed coals, Nos. 1, 2 and 3 being better than the average, No. 4 about equal to it, and No. 5 worse.

48. *Summary.*—The general effect of coal washing as practised in Illinois is therefore to bring the ash and British thermal units in the screenings back to those in the face and in the lump, and to make the sulphur content slightly less than in the face and lump. Disregarding the slight improvement in sulphur content, it might be said that all the Illinois washeries are doing at present is to bring the screenings back to the condition in which they would be in the beginning if mined with the greatest possible care. This is hardly a fair statement of the case, however, since the additional cost of mining so as to exclude all particles of roof and floor and all thick partings would in most cases greatly exceed the cost of washing. Moreover, the larger washed sizes are now better than the face and the smaller sizes would be made so if the demand were sufficiently strong.

B. EFFICIENCY OF WASHING.

The process of coal washing is dependent upon differences in specific gravity and its efficiency may best be measured by methods based upon specific gravities. While the object of coal washing is to reduce the proportion of impurities in the coal, the extent to which it is desired to carry this reduction is commonly stated in terms of ash and British

*Parr, S. W. and Wheeler, W. F. "Unit Coal and the Composition of Coal Ash." U. of I Engineering Experiment Station Bull. 37.

TABLE 15.

BRITISH THERMAL UNITS ON DRY COAL IN ILLINOIS RAW AND WASHED COALS.

Coal Bed	Coal Field	Unit Coal (Free from Ash and Sulphur)	Raw Coal				Washed Coal					
			Face	Mine Run	Lump	Screenings	Screenings	No. 1	No. 2	No. 3	No. 4	No. 5
2	Northern	14 814	13 329	11 895	12 750	10 103	12 903	13 116	12 845			
2	"	14 463	13 221	11 538	13 571	9 874	12 996	13 372	13 655	13 617	12 554	
2	"	14 579	13 613	12 909	13 495	10 239	13 269	13 402	13 281	13 330	13 243	13 209
6	Central	14 390	12 572	12 069	12 417	11 546	12 668	12 704	12 663	12 500	12 655	12 159
6	"	14 365	12 583	11 452	12 669	11 369	12 289	12 636	12 512	12 627	12 327	11 268
6	"	14 365	12 227	11 820	12 649	10 202	13 089	12 870	13 649	13 338	13 182	12 558
6	Southern	14 912	12 907	11 752	12 829	11 172	13 074	13 486	13 465	13 070	13 163	12 140
6	"	14 671	13 366	12 918	13 095	12 651	13 029	13 189	13 196	13 161	12 925	12 799
6	"	14 763	13 229	12 939	13 753	12 397	13 170	13 086	13 253	13 134	13 037	12 687
6	"	14 660	13 030	12 700	13 450	12 103	13 101	13 391	13 280	13 325	13 417	12 233
	Average	14 598	13 007	12 199	13 068	11 166	12 959	13 125	13 180	13 095	12 935	12 445

thermal units when coal is washed for fuel; so when it is desired to ascertain the efficiency of a washery it is necessary to translate ash and British thermal units into specific gravity, since it is upon a specific gravity basis that the coal and refuse are separated in the washery. It has been pointed out that there is a fairly regular increase in ash and decrease in British thermal units with increase in specific gravity in the case of any given coal. Evidently, by effecting a separation at the proper specific gravity any desired proportion of ash within the range of possibility for the coal in question may be obtained.

Separation by means of a solution of high specific gravity is 100 per cent efficient, and while this method is too expensive to be used on a large scale commercially it is admirably adapted to testing. Thus, if a raw coal is tested in heavy solutions of different specific gravities, and the float from each test weighed and analyzed, the specific gravity of a solution that will give float with the desired ash and British thermal units content may be determined. Suppose that 1.35 specific gravity is found to be the right one. The efficiency of the commercial washing process may be determined by testing the products with a solution of this specific gravity. The washed coal will be found to contain a certain amount of material with specific gravity higher than 1.35, and the refuse a certain amount with a specific gravity less than 1.35. Obviously, if the separation at 1.35 had been 100 per cent efficient there would have been no overlap whatever, and the proportions of the amount of overlap are direct measures of the efficiency of the washed coal separation and of the refuse separation respectively. The average of these efficiencies, expressing in a single figure as it does the efficiency of the washery, will be found very useful for purposes of comparison.

The method of determining washery efficiency may be illustrated by the following tests made in the laboratory of the Department of Mining Engineering of the University of Illinois. Samples of 1¼ in. washed coal screenings and refuse from a tub washery treating Bed No. 2 coal in the Northern Field, were tested for sink and float in a zinc chloride solution of 1.35 specific gravity. The estimation of efficiency was made on the basis that a perfect washed coal should contain no heavy or sink particles, and that a perfect refuse should contain no light or float particles. The following is a summary of the results:

	Washed Screenings			Refuse			General Efficiency of Process. Washed screenings plus refuse divided by 2
		Efficiency	Ash	Efficiency		Ash	
Float		91.29%	7.15%		1.21%	9.21%	95.04%
Sink	8.71%		21.44%	98.79%		69.86%	

The lowest washery efficiency comes in the separation of fine coal from fine refuse. Samples of the fine, or No. 5, washed coal and refuse, as produced from Coal Bed No. 6 in the Southern Field, were subjected to the same tests as above, with the results given in Table 16.

TABLE 16.

EFFICIENCY TESTS ON COAL NO. 6 FROM THE SOUTHERN FIELD.

Type of Washery	Product	Washed Coal %	Washed Coal Efficiency %	Washed Coal Ash %	Refuse Efficiency %	Refuse %	Refuse Ash %	General Efficiency of Process. Washed Coal plus Refuse divided by 2. %
Pan Jig	Float Sink	12.75	87.25	4.73 57.48	56 50	43.50	7.00 70.49	71.88
Pan Jig	Float Sink	19.23	80.77	4 56 61 10	90.38	9.62	8.50 87.58	85.58
Piston Jig	Float Sink	22.00	78.00	4.11 35.14	74.20	25.80	6.40 56.30	76.10
Bumping Table	Float Sink	14.73	85.27	4.71 52.66	80 47	19.53	5.71 69.49	82.87
Average	Float Sink	17.18	82.82	4 53 51.60	75.39	24.61	6.90 70.97	79.11

TABLE 17.

PERCENTAGES OF REFUSE PRODUCED AT ILLINOIS WASHERIES.

Field	Washery	Percentage
Northern	1	32
"	2	36
"	3	32
"	4	33
"	5	24
"	6	25
"	7	25
"	8	26
"	9	19
Average Northern		28
Central	14	10
"	15	10
"	17	11
"	18	22
"	19	11
"	20	21
"	22	19
"	23	10
"	24	20
"	25	13
Average Central		15
Southern	28	19
"	31	5
"	32	9
"	33	15
"	35	5
Average Southern		11
General Average		19

C. COMPARISONS.

Owing to the presence of numerous variables, comparisons of the performances of different washeries must be made with great care or they will prove misleading. The results obtained are dependent upon character of coal bed, method of mining, method of raw coal supply to washery, size washed, type of washery, arrangement of washery and operation of washery. A variation in any one of these factors may materially affect the results.

This is evident when considering the proportions of refuse produced at different Illinois washeries, as shown in Table 17. So irregular are these results and so uncertain the causes, that only the most general comparisons can be made with safety. It can be seen that there is, on the whole, a general decrease in the proportion of refuse produced in going from north to south, the average for the Northern field being 28 per cent, for the Central 15 per cent and for the Southern 11 per cent. The percentages given cover all the material thrown away and lost at the washeries, and so include not only the coarse refuse which goes to the dump but also the suspended matter carried away by the water. The amount of this floating refuse is rather difficult of determination, but from several estimates it appears probable that the loss from this source is not infrequently as high as 2½ per cent of the weight of the raw coal washed. Reference to Tables 18 and 19 shows this suspended matter to be always lower in ash than the coarse refuse, while in some instances the ash is seen to be so low as to suggest that the material might profitably be collected and used locally as fuel. The sulphur content of some refuse, as shown in Appendix D, is so high that possibly the pyrite content might be concentrated and sold at a profit.

49. *Different Coalfields.*—The washed coals from the Northern field are on the whole lower in ash than those from the other fields, although in individual cases they may be higher. Southern Illinois coal is next best from point of view of ash content, for though but little refuse is removed from it, it is low in ash at the outset. The average washed coal of the Central field has a slightly higher ash content, while those of the Springfield and Danville fields have still higher. These conclusions are based on Tables, 13, 17 and 18. Table 18, which shows the results achieved at pan jig washeries, is especially valuable for purposes of comparison between the three principal coalfields, since there are more pan jig washeries than all other classes combined. This Table shows the average ash content of washed coals from four Northern washeries to be 8.34 per cent, from two Southern washeries 9.81 per cent and from four Central washeries 12.03 per cent.

50. *Pan Jig and Luhrig Washeries.*—Pan jig washeries of different types give similar results, but the results obtained by different types of piston jig washeries vary considerably. The commonest type of piston jig washery, the Luhrig, gives slightly better results than pan jig washeries, probably because Luhrig washeries always size before washing. The average ash content of the washed coals from two southern Luhrig washeries was 8.99 per cent and of two Central washeries 11.41 per cent as

TABLE 18.

DRY ASH IN PRODUCTS OF ILLINOIS PAN JIG WASHERIES.

Coal Field	Raw Screenings	Washed Coal						Refuse	Suspended Matter	Decrease in Ash Washed Coal under Raw Screenings		Increase in Ash Refuse over Raw Screenings	
		No. 1	No. 2	No. 3	No. 4	No. 5	All Sizes			Amt.	Prop'rt'n	Amt.	Prop'rt'n
	%	%	%	%	%	%	%	%	%	%	%	%	%
Northern	19.17	6.77	4.93	5.13	11.83		9.05	58.68	28.92	10.12	52 79	39.51	206.1
"					7.10			63.59					
"	(27.10)*	5.86	6.60	6.29	6.85	7.07	6 69	63.39		20.41	75 31	39.06	160.5
"	24.47	7.74	7.37	7.91			7.79	58.79		16.68	68.12	34.32	140.3
"	28 87	not made		8.75	9.96		9.83	50.05		19.04	65.95	21.18	73.4
"		not made		9 67	8.61								
Average	24 21	6.79	6.30	7.55	8.71	8.75	8 34	58.90		16.56	65.54	33.49	145.1
Springfield	(16.50)	(11.60)	(12.00)	(12.30)	(12.20)	(12 20)		(5.50)				43.40	374.1
Central						14.83							
"	(16.48)	(9.61)	(9.99)	(10 79)	(10.29)	(12.92)	(10 29)	(57.49)		6.19	37.56	41.01	249.5
"	(19 40)	(9.60)	(10.90)	(10.30)	(11.40)	(14.30)		(57.70)				38.30	197.4
"	(18.30)	(10.30)	(9.70)	(10.40)	(10.90)	18.31	12.52	(72.00)	(22.3)	5.78	31.58	53.70	293.4
"	(25.76)	(11.57)	(6.04)	(10.60)	(8.80)	(14.25)	10.83			14.93	57.96		
"	(26.00)	(10.80)	(10.40)	(10.(0)	(13.80)	19.29	14 47	64 23		11 53	44.35	38 23	147.0
"				(8.05)	(9 22)								
	(26.30)	(8.00)	(11.50)	(12.20)	(12.50)			65.70				39.40	139.8
Average	22.04	9.98	9.76	10.33	10 99	15.65	12.03	63.42		9.61	42.86	42.15	205.4
Southern	13.47	9.09	8.16	8.78				56.02				42.55	315.9
"	13.26	8.96	8.52	7.89	7.42	15.43	9.53	53 48		3.73	28.13	40.22	303.3
"	12.43	9.12	9.00	9.28	10.76	11.46	10.08	42.87	19.02	2.35	18.92	30.44	244 9
"	(16.00)	(11.00)	(10.80)	(10.00)	(8.25)	(13.45)							
"	(10.60)	(8.30)	(7.30)	(7.00)	(8.30)	(10.50)		(60.50)				49.90	470 8
Average	13.15	9 29	8 76	8 59	8.38	12.59	9.81	53.22		3.04	23.53	40.78	333.7
Average of Northern, Southern, andCentral	19.80	8.69	8.27	8.82	9.36	12.33	10.06	58.51	23.41	9.74	43.98	38.81	228.1

* Results in parentheses were not obtained by the writer but are from sources believed to be reliable.

against 9.81 per cent and 12.43 per cent respectively, for pan jig washeries in the same fields.

It is characteristic of the pan jig washeries in the Northern and Southern fields that the ash content of the sizes rises in the order 2, 1, 3, 4 and 5, with the No. 5 washed coal markedly higher than the No. 4. In the Southern field, the order is 4, 3, 2, 1, 5, indicating a more careful washing which is probably due to the small amount of refuse to be removed as compared to the amounts in the other fields. It is characteristic of Luhrig washeries that the No. 3 size of washed coal has a higher ash content than the No. 4. This is owing to the fact that Nos. 4 and 5 are washed together and the bone and shale left are of small sizes which, on screening, go mainly into the No. 5. The Nos. 1, 2 and 3, being washed separately, should have decreasing ash contents, if washed under the best conditions, but as a matter of fact their ash contents increase, as may be seen by consulting Table 19.

Robinson tub washeries in the Northern and Central fields are doing as well as the pan jig washeries. A Forrester washery in the Northern field does not do so well. A Foust jig in the Southern field does not appear to be any improvement on a pan jig. A Campbell bumping table washery in the Southern field holds its own with other types of washeries, the results secured making it appear to be about the equal of a Luhrig washery. Table 20 gives further details of the results obtained in Illinois washeries of different types.

51. *Rescreener and Dry Cleaner.*—So free from bone and shale is some of the coal from the Southern field that the rescreened product may equal some of the washed coals in quality, as will be seen by the figures in Table 20. Dry cleaning is also seen to be very effective in reducing the ash in the No. 1 and No. 2 sizes. The No. 5 coal given beside "Dry Cleaner" in the table was not cleaned. The ash content of the No. 3 and No. 4 sizes is only slightly reduced by the process, but this is probably due to overcrowding rather than to a defect in the method.

XI. Costs of Washing.

The costs of washing coal are hard to determine for three reasons. The washeries do not work regularly throughout the year and a considerable and variable charge for idle time must be made against them. The washeries are frequently run in direct connection with the mine which supplies them with screenings, the same power plant and management serving for both, with the result that the charges which should be made to the washery are not always segregated from those properly belonging to the mine. Finally, the operators of washeries are naturally reticent about letting their business opponents know their costs. Upon the promise that costs supplied would be printed only in such a way that

TABLE 19.

DRY ASH IN PRODUCTS OF ILLINOIS LUHRIG JIG WASHERIES.

Coal Field	Raw Screenings %	Washed Coal No. 1 %	Washed Coal No. 2 %	Washed Coal No. 3 %	Washed Coal No. 4 %	Washed Coal No. 5 %	Washed Coal All Sizes %	Refuse %	Suspended Matter %	Decrease in Ash W'shed Coal under Raw Screenings Amt. %	Decrease in Ash W'shed Coal under Raw Screenings Proportion %	Increase in Ash Refuse over Raw Screenings Amt. %	Increase in Ash Refuse over Raw Screenings Proportion %
Central	(25.60)*	(10 10)	(9.40)	(10.20)	(9.50)	19.49	12.32	68.89	53.20	13.28	51.38	43.29	169.1
"	(20.40)	(7.30)	(8.20)	(13.00)	(9.90)	12.32	10.50	Coarse 38.10 Fine 65.70		9.90	48.53		
Average	23.00	8.70	8.80	11.60	9.70	15 91	11.41			11.59	50.21		
Southern			(8 47)	(8.41)	(8.07)	(8 76)							
"		(5.63)	(8.88)	(8.78)	(7.44)	(14.14)	9.07						
"	13.97	8.39	9 21	9.07	7.66	10.94	8.90	47.30 43.42					
"	(18.95)	(8.51)	(8.70)	(9.95)	(8.26)				47.12	5.07	36.30		
	(15.37)	(8.13)	(5 58)	(7 97)	(9 66)	(8.91)							
Average	16 10	7.67	8.16	8.84	8 22	10 69	8.99						

*Results in parentheses were not obtained by the writer but are from sources believed to be reliable.

TABLE 20.

DRY ASH IN PRODUCTS OF ILLINOIS WASHERIES, DRY CLEANER AND RESCREENER.

Type of Plant	Raw Screenings	Treated Coal						Refuse	Suspended Matter	Decrease in Ash Tr'ted Coal under Raw Screenings		Increase in Ash Refuse over Raw Screenings	
		No. 1	No. 2	No. 3	No. 4	No. 5	All Sizes			Amt.	Proportion	Amt.	Proportion
		%	%	%	%	%	%	%	%	%	%	%	%
Northern Field													
Robinson Washery	29.96	not made			8.36		8.36	69.13	51.98	21.60	72.10	39.17	130.7
Forrester "	28.58	9.74			11.43		11.06	73.18	38.77	17.52	61.30	44.60	164.1
" "					(14.85)*								
Pan Jig Washeries	24.21	6.79	6.30	7.55	8.71	8.75	8.34	58.90	28.92	16.56	65.54	33.49	145.1
Danville Field													
Forrester Washery	(19.30)*			(10.80)	(11.30)	(17.50)		(66.80)				47.50	246.1
New Century "					(9.66)	(16.39)							
Central Field													
Robinson Washery			9.63			13.95		60.14	46.26				
Luhrig Washeries	23.00	8.70	8.80	11.60	9.70	15.91	11.41	68.89	53.20	11.59	50.21	43.29	169.1
Pan Jig "	22.04	9.98	9.76	10.33	10.99	15.65	12.03	63.42	22.30	9.61	42.86	42.15	205.4
Springfield Field													
Pan Jig Washery	(16.50)	(11.60)	(12.00)	(12.30)	(12.20)	(12.20)		55.00				43.40	374.1
Southern Field													
Luhrig Washeries	16.10	7.67	8.16	8.84	8.22	10.69	8.99	Coarse 47.30 Fine 43.42	47.12	5.07	36.30		
Foust Jig	18.90				9.46	11.60	11.31	74.13	16.07	7.59	40.16	55.23	292.2
Pan Jig Washeries	13.15	9.29	8.76	8.59	8.38	12.59	9.81	53.22	19.02	3.04	23.53	40.78	333.7
Campbell Washery		9.33	8.71	8.10	7.53	11.77		57.44	13.98				
Dry Cleaner		9.25	8.43	13.19	13.37	13.55	11.64	46.81	20.35†				
Rescreener		11.83	11.39	11.28	10.10		11.00	56.79‡					

*Results in parentheses were not obtained by the writer but are from sources believed to be reliable.
‡Hand picked. †"Bone."

no one save the operator supplying them could tell to what washery they applied, the writer has kindly been furnished with the figures presented in Table 21.

The costs of power, labor, supplies, repairs and renewals per ton of raw coal washed, as reported by fifteen washeries, varied from 3 to 18 cents, with an average of about 10½ cents. In obtaining this average, depreciation was included in one instance but this is probably more than offset by omission of costs of power from reported general washing costs which are likely to be made when mine and washery are operated with the same power plant, so it is believed that this average is low rather than high. The cost of building fifteen washeries with a combined capacity of 1740 tons raw coal per hour was \$572 000. At the same rate the 33 operating commercial washeries of Illinois with their combined hourly tonnage of 3555 would have cost \$1 169 000. These figures do not represent the total investment in washeries, as they do not include cost of land for washery, reservoirs and refuse dump sites. Costs of individual washeries could not be included in Table 21 without violating the confidences of some of the operators, but costs per ton rated capacity are given. These costs are for washeries with hourly tonnages ranging from 25 to 280 and averaging 116, and show costs of from \$130 to \$583 per ton capacity per hour, with an average of \$351. The costs of individual washeries, while showing considerable irregularity, still vary in a general way with size and type. The average cost per ton capacity per hour of seven washeries with capacities of 100 tons and under was \$448, while eight washeries with capacities in excess of 100 tons averaged \$266. The average cost of three Luhrig jig washeries was \$393 per ton capacity per hour, of six Stewart jig washeries \$341 and of two Robinson tub washeries \$322.

XII. Moisture in Washed Coal.

By Professor S. W. Parr.

The question not infrequently arises as to the amount of excess moisture carried in commercial shipments of washed coal. The particular samples upon which data have been obtained in this Bulletin covering the percentages of ash, sulphur, etc., were not received at the laboratory in a form which made it possible to derive trustworthy conclusions on this point.

In an earlier series of investigations carried on by the Engineering Experiment Station,* however, a large number of car lot shipments were received directly from the washeries. In the majority of cases these car lots were unloaded upon their arrival at the University and sampled in

*University of Illinois Engineering Experiment Station Bulletin No. 39, entitled "Tests of Washed Grades of Illinois Coal."

TABLE 21.

Costs of Washeries and of Washing.

Cost of Washery per Ton Rated Capacity per Hour (Dollars)	Cost of Washing per Ton Raw Coal Washed: Power (Cents)	Labor (Cents)	Supplies Repairs & Renewals (Cents)	Depreciation (Cents)	Insurance (Cents)
280	1.69	7 02	4.60		
375	2 50	7.50	2.19		1.20
583	2.016	13.290	2.671	2.754	0.599
	3.3		0.8	3.4	
294	0.5		10.6	(5—7½%)	
130			6.00		
			15.24		
268			8.60		
563			5.00—10.00		
277			9.50		
400			10.80		
217			3.00	(5%)	
583			16.60		
380					
280			3.00		
280					
350			14.00		
Average 351			10.42		

the process of unloading. It occasionally happened that some of the cars were unloaded into bins before the steam tests were begun. The moisture determination was then made on the coal as it was fired. Where the time of such storage was long and the size of the coal such as to seem to permit of a drying out of the moisture, the storage time is indicated in Table 22. We have thus a very fair indication of the average moisture carried by coals that have passed through the washery and been subjected to such drying out processes as would ordinarily occur in shipment and handling. In every case, also, it has been possible to give a reference factor for the normal moisture in the face samples taken in the usual manner from the same mines, and these factors are included in the table.

One or two points are to be borne in mind in this connection. First, the distance involved in shipment has not a little to do with the water content at the point of delivery. The shipments from Vermilion County to Urbana, for example, cover a distance of approximately 35 miles. As a rule, cars loaded at the Westville mine will be delivered in Urbana the next morning. The moisture increase over the normal or face moisture in this shipment is noticeably higher than the increase indicated for the shipments from Williamson County, which is at a distance of approximately 175 miles.

Another point to be taken into consideration is the fact that the normal or face moisture under ordinary conditions of shipment for unwashed coal will show a decrease in the amount of water present in the car sample. This fact is so well known that it does not need verification here, but it so happens that a number of the samples were duplicated by the unwashed product and received at the laboratory in this form in car lots. Samples 33 to 35 have the advantage, therefore, of giving this data directly. That is to say, with a normal moisture factor in the face of 8.79 per cent, the dry or unwashed coal was received at the University with an average moisture factor of 7.34 per cent. The moisture factors as given, therefore, for the washed coal might well be compared with this factor as the normal one which would accompany the shipments from that distance.

Another point of interest is the general uniformity of the moisture factors for any given series of shipments where conditions of distance and time are approximately constant.

In Table 22 as given, the sizes as obtained by screening at the washery are indicated and this serves to show that the finer sizes retained a higher percentage of moisture and the coarser sizes lost a relatively larger amount of moisture where opportunity presented itself for the drying out of the mass.

52. *Summary.*—Distance, size of the coal and weather conditions are the controlling factors in the amount of moisture retained by washed

TABLE 22.

MOISTURE IN COMMERCIAL SHIPMENTS OF ILLINOIS WASHED COAL.

Table No.	Lab. No.	Source of Sample	Sized by Screening (Inches)	Date of taking car samples	Normal Moisture in Vein Samples	Moisture in Washed Commerc'l Car Shipments as delivered	Remarks
1	220	Himrod Mine	Thru ⅞	Dec. '06	12.96	18.38	New
2	226	Westville,	Over ⅜	"	"	18.63	Century
3	228	Vermilion		"	"	17 35	Washer
4	230	County		"	"	19.11	
5	233			"	"	18 71	
6	‡253			"	"	18.03	
7	243	Shaft A,	Thru ¾	"	9.13	12 24	Stewart
8	246	Herrin	Over ¼	"	"	13.15	Washer
9	249	C & C. C. Co.,		"	"	12.49	
10	255	Williamson		Jan. '07	"	13.13	
11	258	County		"	"	11.30	
12	‡273			"	"	12.14	
13	261	Shaft A,	Thru ¼	"	"	12 41	Stewart
14	264	Herrin	Over 0	"	"	15.80	Washer
15	269	C. & C. C. Co.,		"	"	14.59	
16	271	Williamson		"	"	16.20	
17	284	County		"	"	14.40	
18	286			"	"	17.84	
19	‡303			"	"	15.69	
20	288	Himrod Mine	Thru ⅞	"	12.96	18.68	New Century
21	290	Westville,	Over 0	"	"	19.32	Washer
22	292	Vermilion		"	"	18.33	
23	294	County		"	"	18.79	
24	‡302			"	"	18.78	
25	296	Shaft 2,	Thru ¾	"	10.47	10.72	Stewart
26	274	Peabody C. C.	Over ¼	"	"	10.72	Washer
27	275	Marion		"	"	11.32	
28	276	Williamson Co		"	"	11.23	
29	278	Sh't A, Herrin,	Thru 1¾	Feb. '07	9.13	11.43	Stewart
30	280	C. & C. C. Co.,	Over 1	"	"	10.94	Washer
31	282	Williamson Co	Thru ¾	"	"	10.21	
32	‡304		Over ¼	"	"	10.69	
33	498	Sh't A, Herrin,	Thru 1¾	Apr. '07	"	8.79*	Stewart
34	500	C. & C. C Co.,	Over 1	"	"	8.06*	Washer
35	511	Williamson Co		"	"	8.44*	
36	‡502			"	"	9.60*	
37	520	Sh't A, Herrin,	Thru 1	May '07	"	10.12	In Storage Six
38	541	C. & C. C. Co.,	Over ¾	"	"	9.40	Weeks Before
39	556	Williamson Co		"	"	8.99	Sampling
40	548			"	"	9.38	
41	552			"	"	8.90	Stewart Washer
42	559			"	"	9.74	
43	560			"	"	9.25	
44	‡571			"	"	9.27	
45	561	Shaft No. 2,	Thru ¼	"	10.47	13.94	Stewart
46	563	Marion,	Over 0	"	"	13.97	Washer
47	565	Peabody C.Co.		"	"	21.49	
48	567	Williamson Co		"	"	18.52	
49	569			"	"	17.34	
50	577			"	"	19.27	
51	578			"	"	19.63	
52	579			"	"	19.49	
53	‡587			"	"	18.17	
54	581	Himrod Mine	Thru ⅜	"	12.96	21 61	New Century
55	588	Westville,	Over 0	"	"	21.72	Washer
56	589	Vermilion Co.		"	"	21.35	
57	590			"	"	21.25	
58	‡600			"	"	22.00	
59	591	Himrod Mine,	Thru ⅞	"	"	17.24	New Century
60	592	Westville,	Over ⅜	June '07	"	22.63	Washer
61	594	Vermilion Co.		"	"	17.95	
62	596			"	"	19.83	
63	598			"	"	17.68	
64	601			"	"	16.48	
65	603			"	"	19.29	
66	605			"	"	19.49	
67	‡608			"	"	18.97	

*** Five samples, unwashed, from same mine and of same size gave on delivery in car-lots at Urbana a composite moisture factor of 7.34%**

‡ Composite sample. Proportional weights taken.

coal at the point of delivery. With the finer sizes and the minimum distance, as in the Westville samples, Table 22, table Nos. 54 to 58 being all sizes through a ⅜ in. screen, the moisture content in the washed coal is 9 per cent higher than in the normal or face samples. This represents an increase of very nearly 10 per cent over the original weight of the coal in the mine. The next larger size from the same mine, as shown in table Nos. 20 to 24, namely, all sizes through a ⅞ in. screen, shows an average moisture factor of 18.78 per cent. This is an increase of 5¾ per cent over the normal or face moisture. The next size from the same mine, table Nos. 1 to 5, shows an average moisture content of 18.03 per cent, which is 5 per cent above the normal moisture.

Summarizing the values for the coals subjected to the longer haul, the finest sizes represented are found in table Nos. 13 to 19, the size of coal being all which would pass through a ¼ in. screen. The average moisture for the washed coal is shown to be 15.69 per cent, which is 6.5 per cent higher than the normal or face moisture. The next larger size, namely, through a ¾ in. screen and over a ¼ in. screen, is found in table Nos. 31 and 32, with an average moisture value of 10.69 per cent. This is approximately 1.5 per cent higher than the moisture in the face sample. Table Nos. 25 to 28 are of the same size and the same hauling distance with a moisture factor for the washed coal a little less than 1 per cent above the normal. Another set of values for this same size is shown in table Nos. 7 to 12 in which the increase of moisture in the washed coal is 3 per cent above normal. The largest screen size, as for example, through a 1¾ in. and over a 1 in. screen, as shown in table Nos. 29, 30 and 33 to 36, are not materially different from the screened size between ¼ in. and ¾ in.

The greatest uniformity in moisture increase is shown in the coals having the short haul and the widest variations are shown in the coals with the long haul. Taking into consideration the loss of moisture which would occur in unwashed coals from Williamson County, it may be said that the finer sizes will show an increase of moisture of from 2 to 6 per cent, while the coarser sizes will show an increase of from 2 to 4 per cent above what would normally be the case with unwashed coal at the point of delivery. The increase on the corresponding sizes of washed coals subjected to a short haul would be approximately from 6 to 9 per cent on the finer sizes and approximately 5 per cent on the coarser sizes.

APPENDIX A.

Bibliography of Coal Washing in Illinois.

1874

(1) *Luebbers, H. L.*
"The manufacture of Coke from Illinois Coal." Trans. Am. Soc. C. E. *2* (1874), 163-6, no figs. Contains a very general description of washing Illinois coals by jigging.

1876

(2) *Meier, E. D.*
"Coal Washing in Illinois," Engineering and Mining Journal *22*, 88-90. 3 figs. Also in Engineering News *3*, 228-229, 3 figs. Describes remodeling the Osterspey washery of the Illinois Patent Coke Co. at East St. Louis, Illinois.

1885

(3) *Weeks, J. D.*
"Manufacture of Coke. Illinois." Mineral Resources of the United States, Calendar Years 1883 and 1884, 160-163. Contains brief mention of washeries at Harrison, Saint Johns, Brussels, Equality, Brookside, Streator, and East St. Louis.

1893

(4) *Weeks, J. D.*
"The Manufacture of Coke. Illinois." Mineral Resources, Calendar Year 1891, 378.

Reports failure of attempts to wash Illinois coal sufficiently clean to make good coke.

1896

(5) *(Rutledge, J. J.)*
"The Braceville Coal Washer, Illinois," Eng. and Min. Jour. *62*, 511, 1 fig. Describes 100-ton Howe washery of the Wilmington Coal Washing Co. at Central City.

(6) *Rutledge, J. J.*
"Coal Mining in Illinois," Mineral Industry *4*, 194. Brief reference to coal washing in Illinois.

1897

(7) *Schaefer, J. V.*
"The Washing of Bituminous Coal by the Luhrig Process." Trans. Am. Soc. Mech. Eng. *18*, (1897), 84-90, 4 tables, 3 figs. Reprinted in Mines and Minerals *17*, (1897), 249-253. Reprinted with additional

matter in catalog of Cunninghame & Co. Includes analyses of raw and washed products of 3 Illinois washeries and detailed description of washery of St. Louis & Big Muddy Coal Co. at DeSoto.

1900

(8) *Dinsmore, A.*
"Coal Mines at Streator." Mines and Minerals *21*, 145. Describes Forrester washery of the Illinois Coal Washing Co.

1901

(9) *Breckenridge, L. P.*
"Boiler Tests with Illinois Coals." Jour. West. Soc. Eng. *6*, 230. Briefly refers to benefits derived from washing.

(10) *Kent, W.*
"Steam Boiler Economy," New York, 73. Gives Analysis of washed screenings from Wilmington.

(11) *Schaefer, J. V.*
"Washing of Bituminous Coals by the Luhrig Process." Jour. West. Soc. Eng. (1901), 6 figs. Reprinted in Mines and Minerals *22*, (1902), 366-370. Gives analyses of raw and washed coals at 2 Illinois washeries and list of 4 washeries in operation in Illinois.

1902

(12) *Parr, S. W.*
"The Chemical Analyses and Heating Values of Illinois Coals." Illinois Bur. Labor Stat. *20*, 99-113. Also published separately as a bulletin. Includes 15 analyses of washed coals.

1903

(13) *Bement, A.*
"Shipping Mines and Coal Railroads of Illinois and Indiana." Peabody Coal Co., Chicago, Jan. 1903, 51 and 53. Lists of 21 Illinois Coal Washeries.

(14) *Ross, D.*
"The Southern Illinois Coal Mining & Washing Co., Mine No. 3, Located at Marion, Illinois." Ill. Bur. Lab. Stat., Ann. Rep. *21*, 92, 1 fig. Briefly mentions washery.

(15) *Ross, D.*
"The Acme Coal Co. Mine and Coal Washer, Streator, Illinois." Ill. Bur. Lab. Stat. Ann. Coal Rep. *21*, 98, 1 fig. Briefly mentions washery.

1904

(16) *Bement, A.*
"Washed Coal and Its Preparation," Chapter IV of "The Economical Burning of Coal Without Smoke." Peabody Coal Co., Chicago, 28-37, 4 figs.

Brief description of Stewart washery of Southern Coal Mining & Washing Co. at Marion, Illinois.

(17) *Blakey, D. T.*
"Coal Washing by the Stewart System." Mines and Minerals *24*, 213. Makes brief reference to washing by Stewart system in Illinois.

(18) *Parr, S. W.*
"The Coals of Illinois: Their Composition and Analysis." The University Studies *1*, No. 7, (U. of I. Bull. *1*, No. 20), 24, 30, 31, 35 and 37. Analyses of Illinois washed coals.

(19) *Roberts & Schaefer Co.*
Business announcement. Briefly describes and gives views of 5 Illinois washeries.

1905

(20) *Link-Belt Machinery Co.*
"Washing Bituminous Coal for Coke or Fuel." Special Booklet *42*. Contains views and diagrams of Illinois washeries, lists of those built and those equipped by the company and 3 analyses of Illinois washed coals.

(21) *Parker, E. W., Holmes, J. A., & Campbell, M. R.*
"Preliminary Report on the Operations of the Coal Testing Plant of the U. S. Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904." U. S. Geol. Sur. Bull. *261*. Includes washing test of Illinois slack coal and coking tests of Illinois washed coal.

1906

(22) *Breckenridge, L. P.*
"Tests with Illinois Coals Under Steam Boilers." Ill. Geol. Sur. Bull. *3*, 79-83. Gives brief review of 3 boiler tests of washed coals.

(23) *Breckenridge, L. P.; Parr, S. W.; Dirks, H. B.*
"Fuel Tests with Illinois Coals." U. of I. Eng. Exp. Sta. Bull. *7*, Gives details of 3 boiler tests with washed coals and 23 analyses of washed coals.

(24) *Holmes, J. A.*
"Preliminary Report on the Operations of the Fuel-Testing Plant of the U. S. Geological Survey at St. Louis, Mo., 1905." U. S. Geol. Sur. Bull. *290*. Includes washing tests on Illinois coals and coking and steaming tests on Illinois washed coals.

(25) *Moss, R. S.*
"The Peabody Mines in Southern Illinois." Mining World, *25*, 66-7. Includes brief description of the Stewart washery of the Southern Illinois Coal Mining and Washing Co. at Marion and analyses of washed coals produced.

(26) *Parker, E. W.; Holmes, J. A.; & Campbell, M. R.*
"Report on the Operations of the Coal Testing Plant of the U. S. Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904." U. S. Geol. Sur. Prof. Paper *48*. Includes washing test of Illinois slack and coking tests of Illinois washed coal.

(27) *Parr, S. W.*
"Composition and Character of Illinois Coals, Illinois Geol. Sur. Bull. *3*, 27-78. Gives analyses of 8 washed coals.

(28) *Roberts & Schaefer Co.*
"Coal Washeries, Coal Tipples and Mining Equipment." Bull. *5*. Gives views of 3 Illinois washeries.

1907

(29) *Bement, A.*
"Ash in Coal and Its Influence on the Value of Fuel." Ill. State Geol. Sur. Bull. *8*, 209. Gives average analyses of Illinois washed coals.

(30) *Breckenridge, L. P.*
"How to Burn Illinois Coal Without Smoke." U. of I. Eng. Exp. Sta. Bull. *15*. Includes boiler tests with Illinois washed coals and brief mention of advantages of Illinois washed coal.

(31) *Diescher, S.*
"Process of Coal Washing," Proc. Eng. Soc. Western Pa. *23*, 202. Refers to first washeries in Illinois. Abstract in Iron Age, July 11, 96-100.

(32) *Lord, N. W.*
"Experimental Work Conducted in the Chemical Laboratory of the United States Fuel Testing Plant at St. Louis, Mo., Jan. 1, 1905, to July 31, 1906." U. S. Geol. Sur. Bull. *323*. Reprinted in 1911 as U. S. Bur. of Mines Bull. *28*. Includes specific gravity determinations and 3 washing tests of Illinois coals.

(33) *Parker, E. N.*
"Quantity of Coal Washed at the Mines in 1906." Mineral Resources, Calendar Year 1906, II, 610-511.

(34) *Parr, S. W. & Wheeler, W. E.*
"An Initial Coal Substance Having a Constant Thermal Value." Ill. State Geol. Sur. Bull. *8*, 157. Analyses of Illinois washed coals.

(35) *Roberts and Schaefer Co.*
"Modern Coal Washeries and Mining Plants." Bulletin No. *8*. Contains list with 10 Illinois washeries constructed by the company and views of 5.

(36) *Smith, C. H.*
"Mine No. 17, Collinsville, Ill." Mines and Minerals *28*, 16-17. Includes brief description of Luhrig washery of Consolidated Coal Co. of St. Louis near Collinsville.

1908

(37) *Holmes, J. A.*
"Report of the United States Fuel-Testing Plant at St. Louis, Mo., January 1, 1906, to June 30, 1907." U. S. Geol. Sur. *332*. Includes briquetting test on Herrin No. 5 washed coal and washing tests on 12 Illinois coals.

(38) *Roberts & Schaefer Co.*
"Modern Coal Mining Plants and Coal Washeries." Bull. No. *18*. Contains views and brief descriptions of washeries at Pana and DeCamp, Illinois.

(39) *Parker, C. W.*
"Quantity of Coal Washed at the Mines in 1907." Min. Res., 1907, II, 59-60.

1909

(40) *McGovney, C. S.*
"Tests of Washed Grades of Illinois Coal." U. of I. Eng. Exp. Sta. Bull. *39*, 146 pp. Fully describes boiler tests on 10 grades of Illinois washed coal.

(41) *Moss, R. S.*
"The Carterville Coal Field, Southern Illinois." Mining World, *30*, 676-8. Briefly describes history of coal washing at Brush shaft, Carterville.

(42) *Parker, E. W.*
"Quantity of Coal Washed at the Mines in 1908." Min. Res., 1908, II, 57-58.

(43) *Parr, S. W. and Wheeler, W. F.*
"Unit Coal and the Composition of Coal Ash." (U. of I. Eng. Exp. Sta. Bull. 37). Includes analyses of 2 Illinois washed coals.

(44) *Snodgrass, J. M.*
"The Use of Illinois Coal for Domestic Purposes." Ill. State Geo. Sur. Bull. *14*, 223-228. Includes boiler test on Illinois washed coal.

1910

(45) *Belden, A. W.; Delamater, G. R.; Groves, G. W.; & Way, K. M.*
"Washing and Coking Tests of Coal at the Fuel-Testing Plant, Denver, Colo., July 1, 1908, to June 30, 1909." U. S. Bureau Mines Bull. *5*. Includes tests on coal from Sesser, Illinois.

(46) *Bement, A.*
"The Illinois Coal Field." Ill. State Geol. Sur. Bull. *16*, 195-196. Gives average analyses of 10 washed coals.

(47) *Parker, E. W.*
"Quantity of Coal Washed at the Mines in 1909." Min. Res. 1909, II, 53-4.

(48) *Savage, T. E.*
"The Geology and Coal Resources of the Herrin, Illinois Quadrangle." Ill. State Geol. Sur. Bull. *16*, 284. Makes brief reference to coal washing.

1911

(49) *Fernald, R. H. and Smith, C. D.*
"Resume' of Producer Gas Investigations, October 1, 1904-June 30, 1910." U. S. Bur. Mines Bull. *13*. Includes producer tests on 3 Illinois washed coals.

(50) *Link-Belt Co.*
"Tipples, Coal Washeries and Conveying Machinery for Coal Mines." Cover has title, "The Handling and Preparation of Coal at the Mine." Book No. *111*. Contains views of 3 Illinois washeries.

(51) *Parker, E. W.*
"Coal-Washing Operations." Min. Res. 1910, II, 54-5. Gives quantity of coal washed at Illinois mines.

(52) *Roberts & Schaefer Co.*
"Modern Coal Washing Plants." Bull. *24*. Briefly describes 5 Illinois washers and gives views of 10.

1912

(53) *Allen & Garcia Co.*
"Coal Washery at Panama, Illinois, for Shoal Creek Coal Co." In business announcement. Gives description and views.

(54) *Bement, A.*
"The Screening Problem in Illinois." Coal Age *1*, 1912, 1105, 3 figs. Notes growth of washed coal output and increased demand for No. 4 and No. 5.

(55) *Breckenridge, L. P.; Kreisinger, H.; & Ray, W. T.*
"Steaming Tests of Coals and Related Investigations. September 1, 1904, to December 31, 1908." U. S. B. of M. Bull. *23*. Includes 17 analyses and tests of Ill. washed coals.

(56) *Garcia, J. A.*
"Fireproof Coal Washery, Panama, Ill." Coal Age *1*, 1912, 964-966, 7 figs.

(57) *Parker, E. W.*
"Coal Washing Operations," in Min. Res. 1911, II, 63-64. Gives quantity of coal washed at Illinois mines.

1913

(58) *Bement, A.*
"The Illinois Coal Field." Coal Age *3*, 558-562. Gives sizes of Illinois washed coals.

APPENDIX B.

Chronology of Coal Washing in Illinois.

1870

Osterspey jig washery, 10 tons per hour, under construction by Illinois Patent Coke Co., with Mr. L. Schantl in charge of erection, at East St. Louis to wash coal from the Belleville district for coking in 24 Belgian ovens. This was the first washery in Illinois and the second bituminous coal washery in America. (See 1871).

1871

Piston jig washery erected by St. Louis capitalists at East St. Louis under supervision of Mr. L. Schantl to wash coal for coking in 30 ovens. The plant was a failure and no coke was produced.

The Osterspey jig washery begun at East St. Louis in 1870 was completed and put in operation. (See 1873.)

1872

Piston jig washery erected by Mr. J. J. Endres at Joliet to wash coal for coke.

Piston jig washery erected for Gallatin Coal and Coke Co. at Equality by Mr. J. J. Endres to wash coal for coke. (See 1897.)

1873

The Osterspey jig washery completed at East St. Louis in 1870 was remodeled by Messrs. E. D. and J. W. Meier.

1880

Piston jig washery, 20 tons per hour, erected by Illinois Central Coal and Salt Co. at St. Johns under the supervision of Mr. R. Thomas to wash coal for coking in 18 ovens. (See 1888.)

1882

Washery erected at Brussels to wash coal to supply 50 beehive ovens. Shut down soon because mine was closed.

Prior to 1883

Washery erected at Brookside by Brookside Coal & Coke Co. to wash coal for coking in 6 ovens.

Washery erected at Harrison, Jackson Co., to wash coal from the Big Muddy bed at Carterville, Williamson Co. (See 1886).

1883

Piston jig washery, 35 tons per hour, erected by Luther and Tyler Coal and Coke Co. under supervision of Mr. J. J. Endres on Otter Creek, north of Streator, to wash coal for fuel and for coke making. This was the first bituminous fuel washer. (See 1888.)

1886

The property of the Brookside Coal and Coke Co. was taken over by Consolidated Coal Co. of St. Louis and the washery was not operated again.

1888

The piston jig washery built north of Streator for the Luther and Tyler Coal and Coke Co. in 1883 was moved to the Vermilion River, south of Streator, to obtain better water supply, and its capacity increased to 40 tons per hour. (See 1890.)

The piston jig washery built at St. Johns in 1880 by the Illinois Central Coal and Salt Co. was destroyed by fire on May 30. (For new washery, see 1895.)

1890

Piston jig washery, 27 tons per hour, built for Wilmington Washed Coal Co., successors to Luther & Tyler Coal & Coke Co., on the bank of the Kankakee River at Wilmington to wash coal from the Braidwood district for fuel. (See 1891.)

The piston jig washery built for the Luther and Tyler Coal and Coke Co. south of Streator in 1888 was shut down because it ceased to pay. (For new washery, see above.)

1891

Howe washery, 30 tons per hour, installed by Mr. L. D. Howe, replacing the piston jigs in the washery erected by the Wilmington Washed Coal Co. at Wilmington in 1890. (See 1896.)

1894

Luhrig washery, 60 tons per hour, built for U. S. Coal Washing Co. at the Brush Shaft, Carterville, under direction of Mr. A. Cuninghame with machinery furnished by Link-Belt Co. This was the first washer to wash coal for fuel in the Southern coal field, and the second Luhrig washery in America. (See 1903.)

Forrester washery erected by Illinois Coal Washing Co. at Mine No. 1 of Spring Valley Coal Co., Spring Valley. (See 1903.)

Forrester washery, 50 tons per hour, erected by Himrod Coal Co. at its Pawnee Mine, near Westville. (See 1905.)

1895

Forrester washery, 75 tons per hour, erected by Illinois Coal Washing Co. at Mine No. 1 of the Chicago, Wilmington & Vermillion Coal Co., at Heenanville near Streator, to wash coal for fuel. (See 1905.)

Campbell bumping table washery, 20 tons per hour, erected by Illinois Central Coal & Salt Co. at St. Johns to wash coal for use in making coke. (See 1899.)

1896

Campbell bumping table washery, 40 tons per hour, erected by Big Muddy Coal & Iron Co. at its No. 7 Mine, Herrin, under supervision of Mr. Hiram Willson to wash coal for fuel.

Luhrig washery, 30 tons per hour, erected for St. Louis and Big Muddy Coal Co., at DeSoto under contract with Cuninghame & Co. with machinery furnished by Link-Belt Co. to wash coal for fuel. Acquired later by Inland Steel Co. (See 1908.)

Howe washery, 75 tons per hour built by the Wilmington Washed Coal Co. at Central City in May, the materials and machinery being in part derived from the Howe washery built at Wilmington in 1891.

1897

The piston jig washery erected at Equality in 1872 for the Gallatin Coal and Coke Co. was torn down because worn out. (For new washery see 1901.)

1898

Stewart washery, 75 tons per hour, erected for Big Muddy Coal & Iron Co. at its Harrison Mine, near Murphysboro by E. A. Stewart. This was the first Stewart washery.

Luhrig washery, 60 tons per hour, built for New Ohio Washed Coal Co., Carterville, by Link-Belt Co. (See 1906.)

Luhrig washery, 50 tons per hour, built for Donk Bros. Coal & Coke Co. at its Mine No. 1, Donkville, near Collinsville, by Link-Belt Co. (See 1900.)

Scaife trough washery, 10 tons per hour, erected by Maltby Coal Co. under supervision of J. E. Richmond at Braidwood. (See 1902.)

1899

Stewart washery erected by Chicago & Carbondale Coal Co. at Ward. Later acquired by Mississippi Valley Fuel Co. Abandoned about 1908.

The Campbell bumping table washery, erected in 1895 at St. Johns by the Illinois Central Coal & Salt Co. was shut down because the mine was abandoned.

1900

Howe washery, 50 tons per hour, erected by Acme Coal Co. at Streator in the fall with machinery furnished by Jeffrey Mfg. Co. under supervision of J. R. Holliday. (See 1904.)

Scaife trough washery, 10 tons per hour erected by Gardiner-Wilmington Coal Co., Clarke City.

The Luhrig washery, erected in 1898 for Donk Bros. Coal & Coke Co. at Donkville, near Collinsville, was destroyed by fire. (For new washer, see 1902.)

1901

Stewart washery, 160 tons per hour, built for Chicago & Carterville Coal Co. at its Mine at Herrin by E. A. Stewart.

Piston jig washery, 125 tons per hour, designed by Mr. W. W. Keifer and built by Himrod Coal Co. at its Himrod Mine, Westville. (See 1905.)

Stewart washery, 125 tons per hour, erected by Mr. A. T. Stewart for Southern Illinois Coal Mining & Washing Co. at Marion in April. (See 1911.)

Forrester washery, 100 tons per hour, erected at mine of Chicago, Wilmington & Vermillion Coal Co. at Thayer by and for Illinois Coal Washing Co. in the fall. (See 1911.)

Campbell bumping table washery, 20 tons per hour, erected by and for Gallatin Coal and Coke Co. at Equality. (See 1910.)

1902

Stewart washery, 125 tons per hour, built for Bessemer Washed Coal Co. at East St. Louis by Link-Belt Co. (See 1907.)

Stewart washery, 125 tons per hour, built for Spring Valley Coal Co. at its No. 5 Mine, Dalzell, near Spring Valley by Link-Belt Co.

Stewart washery, 80 tons per hour erected by Mr. E. A. Stewart for Donk Bros. Coal & Coke Co. at its No. 1 Mine, Donkville, near Collinsville.

Stewart washery, 50 tons per hour, built for Illinois Third Vein Coal Co. at its mine at Ladd by Link-Belt Co.

Robinson washery, 50 tons per hour, erected by Wilmington Star Mining Co., with machinery furnished by Link-Belt Co. at No. 5 Mine, Coal City. (See 1911).

The Scaife washery erected at Braidwood in 1898 by the Maltby Coal Co. was burned. (See 1904.)

The Howe washery moved to Central City in 1896 by the Wilmington Coal Washing Co. was sold to T. N. Koehler & Co. (See 1904.)

1903

The Luhrig washery, erected in 1894 at Carterville for U. S. Coal Washing Co. was sold to St. Louis & Big Muddy Coal Co. (See 1911.)

The Forrester washery, erected at Spring Valley No. 1 Mine of the Spring Valley Coal Co. in 1894 was dismantled, because coal from this mine was washed at the Stewart washer erected at Dalzell in 1902.

Prior to 1909

Howe washery, 50 tons per hour, erected by Streator Fuel Co. at Streator. (See 1909.)

Howe washery, 40 tons per hour, erected by Harrison Coal Co. at their mine at Streator under supervision of J. R. Holliday.

1904

Luhrig washery, 125 tons per hour, built for Sunnyside Coal Co. at its Sunnyside Mine, near Herrin, under the supervision of T. G. Warden by Sunnyside Coal Co.

Luhrig washery, 120 tons per hour, built for Consolidated Coal Co. of St. Louis, at its Mine No. 14 near Staunton, by Roberts & Schaefer Co.

American Washery, 100 tons per hour, built for Devlin Coal Co. at Porterfield, near Toluca, by American Coal Washer Co. (See 1909.)

Stewart washery, 60 tons per hour, built for Muddy Valley Mining & Mfg. Co. at Hallidayboro by Roberts & Schaefer Co. (See 1910.)

Luhrig washery, 60 tons per hour, built for Western Coal & Mining Co. at Bush, by Roberts & Schaefer Co.

The Howe washery, 50 tons per hour erected by Acme Coal Co. at Streator in 1900 was burned in the summer and replaced in October.

The machinery from the Scaife washery at Braidwood, burned in 1902, was moved to Central City and erected at the washery of T. N. Koehler & Co. to rewash refuse, but only operated a few days because the refuse contained little coal. (See 1905.)

1905

Luhrig washery, 200 tons per hour, built for Wilson Coal Washery Co. at mine of Carterville Colliery Co., East Carterville, by Roberts & Schaefer Coal Co. (See 1909.)

American washery, 140 tons per hour, built for Lumaghi Coal Co. at Cantine, near Collinsville, by American Coal Washer Co. (See 1911.)

Luhrig washery, 125 tons per hour, built for Consolidated Coal Co. of St. Louis at its Mine No. 15, Mt. Olive, by Link-Belt Co. (See 1907.)

The Forrester washery, erected at Heenanville in 1895 was dismantled and the machinery moved to Mine No. 2 of the Chicago, Wilmington and Vermillion Coal Co. where a new washer was built.

The Forrester washery, built at the Pawnee Mine, Westville, in 1894 was transferred with the mine to the Kelly Coal Co. (See 1907.)

The piston jig washer erected at the Himrod Mine, Westville, in 1901 was transferred with the mine to the Kelly Coal Co. (See 1906.)

The Howe washery at Central City acquired by T. N. Koehler & Co. in 1902 was changed to a Robinson washery with a capacity of 75 tons per hour by the Wilmington Foundry & Machine Co., because the capacity of the Howe washer was too small. Shut down recently because of limited supply of raw screenings.

1906

American washery, 140 tons per hour, built for Madison Coal Corportation at Glen Carbon by American Coal Washer Co.

Luhrig washery, 125 tons per hour, built for Big Muddy Coal & Iron Co. at its No. 8 Mine, Clifford, by Link-Belt Co.

Robinson washery, 100 tons per hour, built for B. F. Berry Coal Co. at Mark, near Granville, by Wilmington Foundry & Machine Co. (See 1908.)

Stewart washery, 90 tons per hour, erected at mine of Royal Collieries Co., near Virden under contract for erection and operation with Carbon Washery Co., who employed Roberts & Schaefer to build the plant. (See 1910.)

Stewart washery, 60 tons per hour, erected at mine of Cardiff Coal Co., Cardiff, under contract for erection and operation with Producers Coal

Co. The washery was built by Roberts & Schaefer Co., being completed in January. (See 1907.)

Stewart washery, 40 tons per hour, erected by Jupiter Collieries Co. at Mine No. 1, DuQuoin. Upon abandonment of Mine No. 1, it was moved to Mine No. 5 and partially erected there.

The Luhrig washery, erected in 1898 at Carterville for New Ohio Washed Coal Co. was shut down because the mine was abandoned.

The washery erected in 1901 at Westville was remodeled into a New Century washery, 60 tons per hour, in August by Link-Belt Co. (See 1907.)

1907

American washery, 280 tons per hour, built for Superior Coal Co. at Gillespie by American Coal Washer Co. Burned July, 1907. (For new washery see 1908.)

Robinson washery, 150 tons per hour, built for Southern Coal & Mining Co. at Lake Station, East St. Louis, by Wilmington Foundry & Machine Co.

American washery, 140 tons per hour, built for Consolidated Coal Co. of St. Louis at its Mine No. 15, Mt. Olive, by American Coal Washer Co. (See 1912.)

Shannon washery, 125 tons per hour, built for Hafer Washed Coal Co. at its mine near Carterville by Link-Belt Co.

Stewart washery, 120 tons per hour, built for Bituminous Coal Washing Co. at mine of Central Washed Coal Co., Pana, by Roberts & Schaefer Co. and turned over to mine owner in August.

Luhrig washery,100 tons per hour, built for Consolidated Coal Co. of St. Louis at its Mine No. 17, in St. Clair County, near Collinsville, by Link-Belt Co.

American washery, 70 tons per hour, built for Shoal Creek Coal Co., at its Mine No. 1, Panama, by American Coal Washer Co. (See 1911.)

Stewart washery, 60 tons per hour, built for the Standard Washed Coal Co. at Bissell, under contract for erection and operation with Producers Coal Co. Roberts & Schaefer Co. built the plant and washing began in February. (See 1910 and 1911.)

Stewart washery, 50 tons per hour, erected at the mine of the De-Camp Coal Co., De-Camp, near Staunton, under contract for erection and operation with Midland Washery Co. Roberts & Schaefer Co. built the plant and it began operating in August. (See 1910 and 1911.)

Stewart washery, erected by Robert Dick Coal Co. at Cambria. (See 1912.)

The Luhrig washery erected in 1905 at Mine No. 15 of the Consolidated Coal Co. of St. Louis at Mt. Olive was burned. For new washer see above.

A Shannon jig was installed at the Stewart washery of the Bessemer Washed Coal Co., erected in 1902 as an experiment. (See 1912.)

The Stewart washery erected in 1906 at Cardiff for the Producers Coal Co. was purchased by the Cardiff Coal Co. in January. (See 1910.)

The Forrester washery erected at the Pawnee Mine, Westville, acquired by the Kelly Coal Co. in 1905, was transferred to the Dering Coal Co., and shut down December 7th, because it was worn out and never had paid.

The New Century washery remodeled in 1906 was again remodeled by Link-Belt Co. practically into a Luhrig washery. (See 1908.)

1908

American washery, 280 tons per hour, built for Superior Coal Co. at Gillespie by American Coal Washer Co. to replace American washery burned in 1907.

Stewart washery, 50 tons per hour, built for Carterville & Big Muddy Coal Co. at its Cambria mine, under contract with Midland Washery Co. It was built by Roberts & Schaefer Co. and turned over to the mine owner in August. (See 1912.)

The Robinson washery, erected in 1906 for B. F. Berry Coal Co. at Mark, near Granville, by Wilmington Foundry & Machine Co. was burned. It was rebuilt by the same company with capacity reduced to 50 tons per hour.

The Luhrig washery erected in 1896 for the Big Muddy Coal Washing Co., DeSoto, was shut down because the mine was abandoned.

The Luhrig washery remodeled from the New Century washery in 1907 for the Dering Coal Co., Westville, was shut down in March because the mine was abandoned.

1909

Shannon and Foust washery, 125 tons per hour, built for Illinois Hocking Washed Coal Co. at White Ash, near Marion, by Link-Belt Co.

Stewart washery, 100 tons per hour, built for Western Washed Coal Co. at mine of Smith-Lohr Coal Mining Co., Pana, by Roberts & Schaefer Co. and put in operation in June. (See 1910.)

Pittsburg washery, 90 tons per hour, built for the Standard Collieries Co. at White Ash by the Pittsburg Coal Washer Co. This washery was of steel and concrete construction and the first fireproof washery in Illinois.

The Howe washery erected prior to 1909 by the Streator Fuel Co. was shut down because the mine did not pay.

The American washery erected at Porterfield, near Toluca, in 1904 for Devlin Coal Co. passed into the hands of Toluca Coal Co.

The Luhrig washery built for the Wilson Coal Washing Co. at Carterville in 1905 passed into the hands of the Taylor Coal Co.

1910

American washery, 80 tons per hour, built by and for Chicago Coal Washer Co. at Tower Hill with jigs supplied by American Coal Washer Co. and machinery by Stephens-Adamson Mfg. Co. This was the first washery in Illinois to use electric power.

New Century washery, experimental, 30 tons per hour, built for Illinois Steel Co. at their coke plant, Joliet, by American Concentrator Co., and put in operation in April to wash coal for coke. (See 1912.)

New Century washery, experimental, 10 tons per hour, installed for L. L. Summers & Co. at Dalton by American Concentrator Co., October 14th, to wash coal for coke.

Bituminous Coal Washing Co., organized on May 14th by consolidation of Producers Coal Co., Carbon Washery Co., Midland Washery Co. and Western Washed Coal Co. (See 1911 and 1912.)

The Stewart washery, erected at Hallidayboro in 1904 for the Muddy Valley Mining & Mfg. Co. passed into the hands of the Muddy Valley Co.

The Stewart washery acquired by the Cardiff Coal Co. at Cardiff in 1907, was shut down because the mine was closed.

The Campbell bumping table washery erected at Equality in 1901 by the Gallatin Coal and Coke Co. was shut down on account of the strike and remained closed because of financial stringency.

1911

Stewart washery, 150 tons per hour, built by and for the Bituminous Coal Washing Co. at the mine of the Chicago, Wilmington & Vermillion Coal Co., Thayer, started operating December 18th.

Shannon washery, 125 tons per hour, erected by Link-Belt Co. at Mine No. 1, Shoal Creek Coal Co., Panama. The Allen & Garcia Co. were engineers for the operators. Fireproof construction.

Stewart washery, 100 tons per hour, built for the Bituminous Coal Washing Co. at Mine No. 3 of the Chicago, Wilmington & Vermillion Coal Co., So. Wilmington, by Roberts & Schaefer Co. in June and sold to the C. W. & V. Co. August 1st.

The Luhrig washery, erected in 1894 at the Brush shaft, Carterville, and later acquired by the Madison Coal Corporation, was shut down in April.

The American washery, erected at Panama in 1907 for Shoal Creek Coal Co. burned down. (For new washer see above.)

The Stewart washery erected at Bissell in 1907 for the Standard Washed Coal Co. and acquired by the Bituminous Coal Washing Co. in 1910, was moved to the No. 7 Mine of the Wilmington Star Mining Co. at Coal City and remodeled.

The Robinson washery erected at Coal City in 1902 for the Wilmington Star Mining Co. at its No. 5 Mine was shut down because the mine was closed and a new washer was erected at No. 7 Mine. (See above.)

The Stewart washery erected at Marion in 1901 for the Peabody Coal Co. was destroyed by fire on June 19th.

The Forrester washery of the Illinois Coal Washing Co. erected at the Thayer Mine of the Chicago, Wilmington & Vermillion Coal Co. in 1901 was dismantled in December. (For new washer see above.)

Electric power installed in the American washery built at Cantine in 1905 by the Lumaghi Coal Co.

1912

Shannon and Foust washery, 150 tons per hour, under construction for Consolidated Coal Co. of St. Louis at its mine No. 7, Staunton, by Link-Belt Co.

Robinson washery, 120 tons per hour, under construction by Southern Coal Co. under supervision of J. E. Richmond on site of old Stewart washer of Bessemer Washed Coal Co. at East St. Louis. Electric power.

Stewart washery, 60 tons per hour, under construction for Geo. B. Pope & Co. at the Big Muddy Fuel Co. mine, Johnston City, by Roberts & Schaefer Co.

Pyrite cleaning plant, 20 tons per hour, built for Mission Field Coal Co. at Oakwood by American Concentrator Co. and put in operation on October 7th.

Experimental washery, 5 tons per hour, equipped with small-size Stewart jig, New Century jigs, Richards pulsator jig and Robinson tub under construction for the Mining Department of the University of Illinois at Urbana by E. M. Burr & Co.

A Richards-Janney classifier was installed by the Allis-Chalmers Co. in the experimental coal washing plant of the Illinois Steel Co. at Joliet, erected in 1910.

A 50-ton Foust rewashing plant to be installed at the Stewart washery erected at Mt. Olive in 1907 was contracted for by the Consolidated Coal Co. of St. Louis with the Link-Belt Co.

The Stewart washery erected at Cambria in 1908 for the Carterville and Big Muddy Coal Co. was shut down in March, because the mine was closed.

The washery of the Robert Dick Coal Co. erected at Cambria in 1907 was purchased, together with the mine, by the Madison Coal Corporation and shut down.

The Stewart washery erected at DeCamp near Staunton in 1907 and acquired by the Bituminous Coal Washing Co. in 1910 was dismantled in October and moved to Pana for storage on account of a disagreement with the mine owner.

The Stewart washery of the Bessemer Washed Coal Co. at East St. Louis to which a Shannon jig was added in 1907, was dismantled.

The Robinson washery erected at Lake Station, East St. Louis for the Southern Coal & Mining Co. in 1907 was destroyed by fire on October 16th. (For new washer see above.)

APPENDIX C.

Illinois Washeries Operating in the Fall of 1912.

No.	Field	County	Town	Company	Offices and Management	Date of Erection
1	Northern	Bureau	Ladd	Illinois Third Vein Coal Co.	Principal Office: Old Colony Bldg., Chicago, S. M. Dalzell, Pres. Local Office: Ladd. F. D. Chadwick, Supt	1902
2	Northern	Bureau	Dalzell	Spring Valley Coal Co	Principal Office: Old Colony Bldg., Chicago, S. M. Dalzell, Gen. Mgr. Local Office: Spring Valley, R. M. Hill, Supt.	1902
3	Northern	Putnam	Granville	B. F. Berry Coal Co.	Office: Granville, J. T. Cherry, Supt.	1908
4	Northern	Marshall	Porterfield	Toluca Coal Company	Main Office: Wichita, Kas., L. C. Jackson, Pres. Operating Office: Toluca, G. B. Gallon, Gen. Mgr.	1909
5	Northern	LaSalle	Streator	Chicago, Wilmington & Vermillion Coal Co.	General Office: McCormick Bldg., Chicago, T. A. Lemmon, Pres. Local Office: 416 N. Vermillion St., Streator, C. A. Herbert, Gen. Supt.	1905
6	Northern	LaSalle	Streator	Acme Coal Co.	Office: 424 Main St., Streator, T. Fairbairn, Pres; E. L. Atkinson, Supt.	1904
7	Northern	LaSalle	Streator	Harrison Coal Co.	Masonic Temple, Streator, R. Gardener, Gen. Mgr.; J R. Holliday, Supt.	1908
8	Northern	Grundy	Coal City	Wilmington Star Mining Co.	General Sales Office: McCormick Bldg., Chicago, Supt's Office: Coal City, W. Campbell, Supt.	1911
9	Northern	Grundy	S. Wilmington, Ill.	Chicago, Wilmington & Vermillion Coal Co.	General Office: McCormick Bldg., Chi- T. A. Lemmon, Pres. Local Office: S. Wilmington, J. Louis, Supt.	1911
10	Northern	Will	Joliet	Illinois Steel Company	Main Office: Joliet Works, D. R. Mathias, Gen Supt. Local Office: Coke Works, C. Wendell, Washer Supt.	1910
11	Northern	Cook	Dalton	Continuous Process Coal Co.	Office: First Nat'l Bank, Chicago, L. L. Summers, Pres.	1910
12	Central	Sangamon	Thayer	Bituminous Coal Washing Co.	Office: McCormick Bldg., Chicago, D. W. Buchanan, Pres. Supt's. Office: Pana, G. N. St. Clair, Supt.	1911

13	Central	Christian	Pana	Bituminous CoalWashing Co.	Office: McCormick Bldg., Chicago, D. W. Buchanan, Pres. Supt's. Office: Pana, G. N. St. Clair, Supt.	1909
14	Central	Christian	Pana	Central Washed Coal Co.	Office: Fisher Bldg., Chicago, W. E. Zoller, Pres.; R. H. Zoller, Gen. Mgr.	1907
15	Central	Shelby	Tower Hill	Chicago Coal Washing Co.	Office: Fisher Bldg., Chicago, W. J. Shedd, Pres.; F. Gascoigne, Gen. Mgr. Local Office, Tower Hill, F. L. Anderson, Supt.	1910
16	Central	Macoupin	Virden	Royal Colliery Co.	Home Office: Land Title Bldg., Phila., Pa., D. B. Wentz, Pres. Sales Office: Monadnock Bldg., Chicago, A. J. Maloney, V. P. Local Office: At Washer, J. B. Falcetti, Supt.	1906
17	Central	Macoupin	Gillespie	Superior Coal Co.	Main Office: J. P. Reese, Gen. Supt. Local Office: Gillespie, J. H. Ross, Supt.	1908
18	Central	Macoupin	Mt. Olive	Consolidated Coal Co. of St. Louis.	General Office: Syndicate Trust Bldg., St. Louis, Mo., W. L. Schmick, Vice Pres. and Gen. Mgr. Local Office: Staunton, Ill., F. E. Weissenborn, Supt.	1907
19	Central	Macoupin	Staunton	Consolidated Coal Co. of St. Louis.	General Office: Syndicate Trust Bldg., St. Louis, Mo., W. L. Schmick, Vice Pres. and Gen. Mgr. Local Office: Staunton, Ill., F. E. Weissenborn, Supt.	1904
20	Central	Madison	Glen Carbon	Madison Coal Corporation	General Offices: Central Nat'l Bank, St. Louis, Mo., A. J. Moorshead, Pres. and Gen. Mgr. Local Office: Glen Carbon, A. Daenzer, Dist. Supt.	1906
21	Central	Madison	Donkville	Donk Bros. Coal & Coke Co.	314 N. 4th St., St. Louis	1902
22	Central	Madison	Cantine	Lumaghi Coal Co.	Office: Equitable Bldg., St. Louis, Mo., L. F. Lumaghi, Pres.	1905
23	Central	Bond	Panama	Shoal Creek Coal Co.	General Office: Fisher Bldg., Chicago, F. P. Blair, Pres. Local Office: Panama, E. H. Ross, Gen. Mgr.; N. Shannon, Supt.	1911
24	Central	St. Clair	Caseyville Township, near Collinsville	Consolidated Coal Co. of St. Louis.	General Office: Syndicate Trust Bldg., St. Louis, Mo., W. L. Schmick, Vice Pres. and Gen. Mgr. Local Office: Collinsville, P. Grieve, Jr., Supt.; H. P. Altman, Washery Supt.	1907

25	Central	St. Clair	Lake Station E.St. Louis	Southern Coal & Mining Co.	Office: Security Bldg., St. Louis, Mo., W. K. Kavanaugh, Pres.; J. E. Richmond, Supt...	1907
26	Southern	Jackson	Harrison	Big Muddy Coal & Iron Co.	General Office: Wainwright Bldg., St. Louis, O. L. Garrison, Pres. Dist. Office: Herrin, H. Willson, Mgr. Local Office: E. Walnut St., Murphysboro, J. Forester, Supt.	1898
27	Southern	Jackson	Halliday-boro	Muddy Valley Mining & Mfg. Co.	Sales Agt: Carterville Washed Coal Co., Fisher Bldg., Chicago, J. C. Smith, Pres. Local Office: Hollidayboro, J. Forester, Supt.	1904
28	Southern	Williamson	Bush	Western Coal & Mining Co.	Main Office: Syndicate Trust Bldg., St. Louis, W. J. Jenkins, Pres. Local Office: Bush, E. W Hogan, Supt.	1904
29	Southern	Williamson	Clifford	Big Muddy Coal & Iron Co...	General Office: Wainwright Bldg., St. Louis, O. L. Garrison, Pres. District Office: Herrin, H. Willson, Mgr.	1906
30	Southern	Williamson	Herrin	Big Muddy Coal & Iron Co...	General Office: Wainwright Bldg., St. Louis, O. L. Garrison, Pres. District Office: Herrin, H. Willson, Mgr.	1896
31	Southern	Williamson	Herrin	Chicago & Carterville Coal Co.	Sales Office: Old Colony Bldg., Chicago, J. Pease, Pres. General Office: Herrin, J. D. Peters, Vice Pres. and Gen. Mgr..	1901
32	Southern	Williamson	Herrin	Sunnyside Coal Co.	Main Office: Fisher Bldg., Chicago, T. G. Warden, Pres. Local Office: Herrin, J. Rollo, Supt.	1904
33	Southern	Williamson	Carterville	HaferWashed Coal Co.	Main Office: McCormick Bldg., Chicago. Local Office: Carterville, J. McGonigal, Supt.....	1907
34	Southern	Williamson	Carterville	Taylor Coal Co.	Main Office: Old Colony Bldg., Chicago, H. H. Taylor, Pres. Local Office: Carterville, P. H. Carroll, Supt.	1905
35	Southern	Williamson	White Ash	Illinois Hocking Washed Coal Co.	Main Office: Fisher Bldg., Chicago, S. M. Goodall, Pres, Local Office: Marion, G. B. Calhoun, Supt.	1909

APPENDIX D.

Analyses of Illinois Washed Coals and Related Products.

Analyses performed by the Chemical Department of the University of Illinois, under the direction of Prof. S. W. Parr.

Dry Basis.

No.	Bed	Field	Coal	Vol. Matter	Fixed C	Ash	Sulphur	BTU	Unit Coal BTU
1	2	Northern	Raw Screenings	36.64	34.49	28.87	4.64	9870	14542
2	2	"	Washed Nut	43.10	48.15	8.75	3.59		
3	2	"	" Slack	45.04	45.00	9.96	3.56		
4	2	"	Refuse	27.48	22.47	50.05	9.35		
5	2	"	Raw Screenings	35.51	34.53	29.96	5.63	9645	14506
6	2	"	Washed Screenings	45.02	46.62	8.36	3.88		
7	2	"	Refuse	21.37	9.50	69.13	22.01		
8	2	"	Suspended Matter	24.81	23.21	51.98	5.94		
9	2	"	Raw Screenings	36.79	38.74	24.47	4.95	10666	14704
10	2	"	No. 1 Washed Coal	43.68	48.58	7.74	3.24		
11	2	"	No. 2 " "	45.18	47.45	7.37	3.74		
12	2	"	No. 3 " "	43.00	49.09	7.91	3.30		
13	2	"	Refuse	24.83	16.38	58.79	8.06		
14	2	"	Raw Screenings	37.61	33.81	28.58	3.93	10103	14789
15	2	"	Washed Nut	45.34	44.92	9.74	3.72		
16	2	"	" Slack	43.98	44.59	11.43	3.77		
17	2	"	Refuse	19.84	6.98	73.18	4.57		
18	2	"	Suspended Matter	31.77	29.46	38.77	3.79		
19	2	"	No. 1 Washed Coal	44.69	48.54	6.77	2.72		
20	2	"	No. 2 " "	46.43	48.64	4.93	2.55		
21	2	"	No. 3 " "	45.26	49.61	5.13	2.78		
22	2	"	No. 4 & No. 5 W. Coal	43.87	44.30	11.83	3.18		
23	2	"	Refuse	24.94	16.38	58.68	5.27		
24	2	"	Suspended Matter	31.77	39.31	28.92	2.72*	9653	14147
25	2	"	No. 4 & No. 5 W. Coal	32.35	60.55	7.10	3.05		
26	2	"	Refuse	25.55	10.86	63.59	6.77		
27	2	"	Raw Screenings	39.12	43.46	17.42	3.31	11586	14389
28	2	"	No. 1 Washed Coal	45.21	48.93	5.86	2.64		
29	2	"	No. 2 " "	44.50	48.90	6.60	2.80		
30	2	"	No. 3 " "	44.63	49.08	6.29	2.81		
31	2	"	No. 4 " "	43.66	49.49	6.85	2.78		
32	2	"	No. 5 " "	43.60	49.33	7.07	2.74		
33	2	"	Refuse	24.29	12.32	63.39	4.71		
34	6	Central	Pyrite Crystal	25.97	7.24	66.79			
35	6	"	No. 5 Washed Coal	38.98	42.71	18.31	4.77*		
36	6	"	No. 5 " "	44.63	43.05	12.32	4.15*	12089	14070
37	6	"	No. 5 " "	41.65	39.06	19.29	4.83*	11132	14235
38	6	"	Refuse	23.54	12.23	64.23	16.55*		
39	6	"	No. 5 Washed Coal	41.60	43.57	14.83	3.4[illegible]*	12004	14416
40	6	"	No. 5 " "	40.22	40.37	19.41	4.33*		
41	6	"	Refuse	22.55	8.56	68.89	12.57*		
42	6	"	Suspended Matter	25.04	21.76	53.20	2.67*		
43	6	"	Tank Washings	38.46	38.36	23.18	3.53*		
44	6	"	No. 2 Washed Coal	43.71	46.66	9.63	4.26*	12649	14251
45	6	"	No. 5 " "	43.39	42.66	13.95	4.19*		
46	6	"	Refuse	25.49	14.37	60.14	22.45*		
47	6	"	Suspended Matter	26.76	26.98	46.26	3.28*		
48	6	Southern	Washed Egg Coal	37.26	53.11	9.63	1.82*		
49	6	"	No. 1 Washed Coal	38.01	52.96	9.03	1.18*		
50	6	"	No. 2 " "	35.25	56.04	8.71	1.66*	13171	14593
51	6	"	No. 3 " "	37.22	54.68	8.10	1.73*		
52	6	"	No. 4 " "	36.63	55.84	7.53	1.48*		
53	6	"	No. 5 " "	33.79	54.44	11.77	2.26*		
54	6	"	Refuse	20.24	22.32	57.44	10.42*		
55	6	"	Hand Picked Refuse	17.08	13.76	69.16	3.54*		
56	6	"	Suspended Matter	26.53	59.49	13.98	7.19*		
57	6	"	Shale	7.19	.93	91.88			
58	6	"	Raw Screenings	36.77	50.80	12.43	1.87	12651	14679
59	6	"	No. 1 Washed Coal	35.67	55.21	9.12	1.40		
60	6	"	No. 2 " "	36.38	54.62	9.00	1.55		
61	6	"	No. 3 " "	35.34	55.38	9.28	1.52		
62	6	"	No. 4 " "	34.89	54.35	10.76	1.57		
63	6	"	No. 5 " "	33.[illegible]8	54.66	11.46	1.38		
64	6	"	Refuse	25.26	31.87	42.87	4.34		
65	6	"	Suspended Matter	29.73	51.25	19.02	1.53		

*Sulphur determinations marked with a star were not made in duplicate.

No.	Bed	Field	Coal	Vol. Matter	Fixed C.	Ash	Sul-phur	BTU	Unit Coal BTU
66	6	Southern	Raw Screenings	35.65	50.38	13.97	3.35	12191	14475
67	6	"	No. 1 Extra Washed Coal	37.29	54.84	7.87	2.98		
68	6	"	Washed Stove Coal	37.29	54.02	8.69	2.53		
69	6	"	" Chestnut Coal	37.21	53.58	9.21	2.54		
70	6	"	No. 2 Washed Coal	37.19	53.74	9.07	2.52		
71	6	"	No. 4 " "	37.44	54.90	7.66	2.40		
72	6	"	No. 5 " "	36.31	52.75	10.94	2.47		
73	6	"	Refuse	25.09	27.61	47 30	13.67		
74	6	"	Fine Refuse	27 01	29 57	43.42	6.33		
75	6	"	Raw Screenings	33.68	53.06	13.26	2.60	12514	14699
76	6	"	No. 1 Washed Coal	35.91	55.13	8.96	2.09		
77	6	"	No. 2 " "	36 27	55 21	8.52	2.00		
78	6	"	No. 3 " "	34.99	57 12	7.89	1.99		
79	6	"	No. 4 " "	36.29	56.29	7.42	1.82		
80	6	"	No. 5 " "	33.48	51.09	15.43	2.88		
81	6	"	Refuse	21.93	24.59	53.48	10.03		
82	6	"	Raw Screenings	35.88	50 65	13.47	2.61	12397	14598
83	6	"	No. 1 Washed Coal	37.56	53.35	9.09	2.60		
84	6	"	No. 2 " "	37.38	54.46	8.16	1.93		
85	6	"	No. 3 " "	38 05	53.17	8.78	2.64		
86	6	"	No. 4 " "	39.98	50.56	9 46	2.31		
87	6	"	No. 5 " "	36 55	51.85	11.60	2.72		
88	6	"	Coarse Refuse	23.49	20 49	56.02	10.25		
89	6	"	Fine Refuse	18.35	7.52	74.13	10.03		
90	6	"	Suspended Matter	28.12	55.81	16.07	1.93		
91	6	"	No. 1 Cleaned Coal	36.78	53.97	9 25	1.04		
92	6	"	No. 2 " "	35 84	55.73	8 43	.91		
93	6	"	No. 3 " "	35.52	51.29	13.19	1.62		
94	6	"	No. 4 " "	35.30	51.33	13.37	1.11		
95	6	"	No. 5 Raw Coal	34.49	51.96	13.55	1.39		
96	6	"	"Bone" from Cleaner	32.20	47.45	20.35	1.92		
97	6	"	"Slate" " "	22.03	31 16	46.81	3.13		
98	6	"	Rescreened No. 1 Coal	35.21	52.96	11.83	2 87	12688	14646
99	6	"	" No. 2 "	35.52	53.09	11.39	2 64		
100	6	"	" No. 3 "	35.47	53.25	11.28	2.53		
101	6	"	" No. 4 & 5 Coal	35.55	54.35	10.10	2.46		
102	6	"	Hand Picked Refuse	20.76	22 45	56 79	4.84		

APPENDIX E.

SCREENS IN ILLINOIS WASHERIES.

I. FIXED SCREENS

(a) SIZING RAW COAL

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Travel of Drag Feet per Minute	Openings Diam. (Ins.)	Openings Shape	Length of Screening Surface (Feet)	Feed Diameter (Inches)	Feed Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
30	1a	Drag	24	2	Level	180	3/8	Round	8	3 3/4–0	40	....	0.2
	b						1 3/4	Slot	16	3 3/4–3/8	...	....	...

(b) RESIZING WASHED COAL SIZED PRIOR TO WASHING

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Travel of Drag Feet per Minute	Openings Diam. (Ins.)	Openings Shape	Length of Screening Surface (Feet)	Feed Diameter (Inches)	Feed Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
20	2	Drag	8	3	10	...	1/16	Round	8	3/4–0	25	(Rinsings only)	1.0
	3	Gravity	4	1	36	...	3/4	"	4	1 3/4–1 1/8	19	(Supplementing Revolving Screen No. 25).....	0.2
	4	"	3	1	31	...	1 1/8	"	3	3–1 3/4	20	(Supplementing Revolving Screen No. 26).....	0.2
24	5	"	.....	.....	....	.....	3/8	"	.....	1 3/4–1	18	(Supplementing Revolving Screens Nos. 27 and 28)..................	...
32	6	"	8	1 1/2	....	...	1/4	"	8	3/4–0	54	(Relieving Revolving Screens No. 48).......	0.2
	7	Drag	10	3	11	60	3/16	"	10	3/8 & 1/4–0	23	(Rinsings only)	1.3
34	8	"	16 & 22	4	Level	40	3/16	"	16 & 22	3/8–0	...	" "	...
35	9	Gravity	4	4	....	...	3/4	"	4	3–0	65	(Relieving Revolving Screens No. 57......	0.2
	10	Drag	15	3	10	60	1/4	"	15	3/4–0	43	23	1.0

(c) SIZING WASHED COAL

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Travel of Drag Feet per Minute	Openings Diam. (Ins.)	Openings Shape	Length of Screening Surface (Feet)	Feed Diameter (Inches)	Feed Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
3	11a	Drag	20	4	40	100	3/32	Round	12	7/8–0	...	(Rinsings only)	...
	b	"					1/16	"	8	7/8–3/32	...	" "	...
7	12	"	9	2 1/2	....	60	1/16	"	9	1 1/2 slot–0	...	" "	...
14	13	Gravity	..	..	....	...	1 1/2x2 3/8	Elliptical	..	3 1/2–1 3/4 sq.	...	....	...
	14	"	..	..	....	...	1 3/8	Round	..	1 3/4 sq.–1 3/8 r. & 1 sq.	...	....	...
	15	"	..	..	....	...	..	Elliptical	..	1 3/8 r. & 1 sq. –7/8	...	....	...
	16	"	..	..	....	...	1/4	Round	..	7/8–1/4	...	....	...
18	17	"	3	1	....	...	3/4	"	3	1 1/8–3/4	...	(Supplementing Shaker Screen No. 27c).......	...
21	18	Drag	12	2	4 1/2	...	3/16	"	12	3/8–0	...	....	...
22	19	Gravity	6	1 1/2	31	...	3/4	"	6	3–1 3/4	1	(Supplementing Revolving Screen No. 76a)....	9.0

I. (c) SIZING WASHED COAL (Continued)

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Travel of Drag Feet per Minute	Openings		Length of Screening Surface (Feet)	Feed		Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
							Diam. (Ins.)	Shape		Diameter (Inches)	Tons per Hour		
22	20	Gravity	..	..	....	...	¾	Round	..	1¾–¾	43	(Supplementing Revolving Screen No. 76a)....	...
25	21	Drag	16	3½	Inclined	60	¼	"	16	3–0	131	28	0.4
26	22	"	13	4	7½	240	¼	"	13	1¼–0	...	....	...
27	23	Gravity	..	..	....	...	⅛	"	..	....	...	(Rinsings only)	...
31	24a	Drag	28	3	16	120	$\frac{7}{16}$	"	7	3–0	76	25	1.1
	b						⅜	"	21	3–$\frac{7}{16}$			
	25a	"	28	3	16	120	$\frac{7}{16}$	"	7	3–0	76	25	1.1
	b						⅜	"	21	3–$\frac{7}{16}$			
	26	Double-decked Drag	12	3½	Level	90	$\frac{5}{16}$	"	12	$\frac{7}{16}$ & ⅜–0	38	(Rinsings only)	1.1
33	27	Gravity	1¼	3	22	...	$\frac{5}{16}$	"	1¼	3½–1¾	25	(Supplementing Revolving Screen No. 90a)....	0.2
	28	"	4	2	21	...	$\frac{5}{16}$	"	4	3½–1¾	25	(Supplementing Revolving Screen No. 90a)....	0.3
	29	"	3	2	38	...	¾	Slot	3	1¾–1	22	(Supplementing Revolving Screen No. 90b)...	0.3
	30	"	1⅙	2	31	...	½	Square	2	1–¾	23	(Supplementing Fixed Screen No. 29)........	0.1
	31	"	1⅚	3	32	...	½	"	3	¾–0	42	(Supplementing Revolving Screen No. 90c)....	0.1

II. SHAKING SCREENS

(a) SIZING RAW COAL

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Shakes: No. per Minute	Shakes: Length (Inches)	Openings: Diam. (Ins.)	Openings: Shape	Length of Screening Surface (Feet)	Feed: Diameter (Inches)	Feed: Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
32	1	Rod suspension	7	6	10	132	5	¾	Round	7	3½–0	62½	52	0.7
	2	" "	7	6	10	132	5	¾	"	7	3½–0	62½	52	0.7

(b) RESIZING WASHED COAL SIZED PRIOR TO WASHING

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Shakes: No. per Minute	Shakes: Length (Inches)	Openings: Diam. (Ins.)	Openings: Shape	Length of Screening Surface (Feet)	Feed: Diameter (Inches)	Feed: Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
2	3a	Rod suspension	13	8	9	180	2½	⅜	Round	13	¾–0	71	....	1.5
	b	double-deck, baffle plates on upper deck			7			3/16	"	13	⅜–0	..	(Rinsings only)	...
29	4a	Rod suspension, double	8	4	8	140	4½	2¾	"	8	3–1¾	..	....	...
	b	deck......						1¾	"	8	2¾–1¾	..	(Breakage only)	...
	5	Rod suspension	8	4	8	140	4½	1¾	"	8	3–1¾	..	" "	...
	6	" "	8	4	8	140	4½	1	"	8	1¾–1	..	" "	...
	7	" "	8	4	8	140	4½	1	"	8	1¾–1	..	" "	...
	8	" "	8	4	8	140	4½	⅝	"	8	1–¾	..	" "	...
	9	" "	8	4	8	140	4½	⅝	"	8	1–¾	..	" "	...
	10a	" "	12	4	8	140	4½	⅜	"	4	¾–0	..	....	...
	b							3/16	"	8	⅜–0	..	....	...
	11a	" "	12	4	8	140	4½	⅜	"	4	¾–0	..	....	...
	b							3/16	"	8	⅜–0	..	....	...
30	12	" "	10½	4½	10	144	4½	¼	"	10½	3¾–0	40	....	1.2
	13	"	7	3½	15	176	4½	¼	"	7	¾–¼	..	(Breakage only)	...
	14	"	7	3½	15	176	4½	¼	"	7	¾–¼	..	" "	...
	15	"	7	3½	15	176	4½	¾	"	7	1–¾	..	" "	...
	16	" "	7	3½	15	176	4½	1	"	7	1¾–1	..	" "	...
	17a	Rod suspension, double	7	3½	15	176	4½	1¾	"	7	3¾–1¾	..	" "	...
	b	deck.....						3	"	7	3¾–1¾	..	....	...
Average					10½	155	4½							1.35

II. (c) SIZING WASHED COAL

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Shakes: No. per Minute	Shakes: Length (Inches)	Openings: Diam. (Ins.)	Openings: Shape	Length of Screening Surface (Feet)	Feed: Diameter (Inches)	Feed: Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
1	18	Rod suspension	9	3	8	160	2½	⅛	Round	9	¾–0	31	(Rinsings only)	0.9
3	19	Supported Parrish...	10	4	4	132	6	15/16	"	10	⅞ slot–0	34	(Just installed)	1.2
6	20	Roller support...	14	4	18	40	5	1/16	"	14	2¼ & 2½–0	38	(Rinsings only)	1.5
8	21a	Supported Parrish double deck	24	4	4	120	6	¾	"	12	2x3½ ell.–0	44	57	1.1
	b							⅜	"	12	¾–0	..	....	...
	c							1¾	"	12	2x3½ ell.–¾	25	81	1.9
	d							1¼	"	12	1¾–¾	20	66	2.4
9	22a	Rod suspension, tandem screens double decked	20	6	6	148	6	1½	"	16	3–5/16	55	87	1.7
	b							2¼	"	12	3–1½	7	66	10.3
	c		20		5			5/16	"	12	1½–5/16	48	(Supplementing Rev. Screen No. 63)	1.5
	d							1/16	"	8	5/16–0	26	(Rinsings only)	1.8
	e							¾	"	12	1½–5/16	48	43	1.5
12	23a	Supported Parrish, tandem screens, fastened together	22	5	5	124	6	¾	"	22	3–5/16	..	....	...
	b							5/16	"	22	¾–5/16	..	(Supplementing Rev. Screen No. 64)	...
	c							1/16	"	22	5/16–0	..	(Rinsings only)	...
	d							1¼	"	10	3–¾	..	....	...
	e		20	4	7			1¾	"	10	3–1¼	..	....	...
13	24a	Hung Parrish, pair, one above other	19	5	5	126	6	2⅞	"	18½	3½–5/16	..	....	...
	b			6				2¼	"	18½	2⅞–5/16	..	....	...
	c			7				1¾	"	18½	2¼–5/16	..	....	...
	d		24	6				¾	"	16½	1¾–5/16	..	....	.....
	e			6				1¼	"	7½	1¾–¾	..	....	...
	f			7				5/16	"	18½	¾–5/16	..	(Supplementing Rev. Screen No. 65)	...
15	25a	" "	12	6	4	130	4	2½	"	12	3½–0	..	....	..
	b			6				1¼	"	12	2½–0	..	....	...
	c			7				⅞	"	12	1¼–0	..	....	...
	d			7				⅝	"	4	⅞–0	..	....	...
16	26a	" "	12	5	5	144	6	1⅞	"	12	3–5/16	..	....	...
	b			5	5			1¼	"	12	1⅞–5/16	..	....	...
	c			6	14 & 5			⅞	"	12	1¼–5/16	..	....	...
	d			6	2½			¼	"	9	⅞–5/16	..	....	...
	e			7	2½			1/16	"	8	5/16 & ¼–0	..	....	...
18	27a	Hung Parrish	13	6	4½	150	4	1¾	"	13	3–0	109	86	0.7
	b							1⅛	"	13	1¾–0	94	79	0.8

II. (c) SIZING WASHED COAL—(Continued)

Washery No.	Screen No.	Type	Length (Feet)	Width (Feet)	Slope (Degrees)	Shakes: No. per Minute	Shakes: Length (Inches)	Openings: Diam. (Ins.)	Openings: Shape	Length of Screening Surface (Feet)	Feed: Diameter (Inches)	Feed: Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
	c	Hung Parrish						¾	Round	13	1⅛–0	74	82	1.1
21	28a	Rod suspension, pair, one above other	40	4¾	16	78	8	¼	"	6	2 & 1¼–0	..	....	...
	b				16			1	"	16	2 & 1¼–¼	..	....	...
	c				16			1½	"	16	2 & 1¼–1½	..	....	...
	d				16			⅜	"	16	1–¼	..	....	...
	e				16			¼	"	12	⅜–¼	..	(Supplementing a)	...
	f				14			⅜	"	16	1–⅜	..	(Supplementing d)	...
23	29a	Hung Parrish, pair, one above other	10½	6	4	128	6	1¾	"	10½	3–0	113	17	0.6
	b			6	4			1¼	"	10½	1¾–0	94	15	0.7
	c		12	7	5			¾	"	12	1¼–0	80	29	1.1
25	30a	Rod suspension, pair, one above other, each doubledecked	16	4	21	158	4	2	"	16	3–¼	94	4	0.7
	b							1⅛	"	16	2–¼	90	25	0.7
	c							$\frac{11}{16}$	"	16	1⅛–¼	67	41	1.0
	d							¼	"	16	$\frac{11}{16}$–¼	40	(Supplementing Fixed Screen No. 21)	1.6
	31	Rod suspension	6	3	...	156	..	1	"	6	2–1⅛	23	(Supplementing Screen No. 30b)	0.8
	32	" "	6	3	..	156	..	1½	"	6	3–2	4	(Supplementing Screen No. 30a)	4.5
27	33	" "	5	4	..	160	3	2	"	5	3–2	..	(Supplementing Rev. Screen No. 87a)	...
	34	" "	5	4	..	160	3	1	"	5	2–1	..	(Supplementing Rev. Screen No. 87b)	...
	35	" "	5	4	..	160	3	¾	"	5	1–¾	..	(Supplementing Rev. Screen No. 87c)	...
	36	" "	4	4	..	200	3	¼	"	4	¾–0	..	....	...
31	37a	Rod suspension, double decked	10	3	15	130	..	$\frac{11}{16}$	"	10	3–1¾	..	(Supplementing Rev. Screen No. 88a)	...
	b			3½	20			¼	"	6	1¾–1¼	..	(Supplementing Rev. Screen No. 88b)	....
Average	....					138	5							1.7

III. REVOLVING SCREENS

(a) SIZING RAW COAL

Wash-ery No.	Screen No.	Type	Length (Feet)	Dia. (Feet)	Slope (Degrees)	R. P. M.	Peripheral Speed Feet per Minute	Openings		Length of Screening Surface (Feet)	Feed		Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
								Diam. (Ins.)	Shape		Diameter (Inches)	Tons per Hour		
2	1	Cylindrical	9	5	7	18	283	¾	Square	9	1⅛–0	125	89	1.1
19	2a	Triple-jacketed, cylindrical	14	6	5	12	200	1¾	Round	14	3–0	120	90	2.2
	b			8			301	1	"	14	1¾–0	108	74	3.3
	c			10			377	¾	"	14	1–0	80	65	5.5
20	3	Cylindrical	14	5	3	30	471	9/16	Square	14	1¼–0	140	......	1.5
24	4a	Triple-jacketed, conical	10½	3 & 5	Axis level	12	151	1¾	Round	10½	3–0	100	83	1.3
	b		10	5 & 7			200	1	"	10	1¾–0	83	89	2.3
	c		9½	7 & 9			301	¾	"	9½	1–0	74	77	3.2
28	5a	Triple-jacketed, cylindrical	9	4½	3	16	226	2	"	9	3–0	60	90	2.1
	b			5¾			289	1	"	9	2–0	54	69	3.0
	c			7			352	¾	"	9	1–0	37	86	5.3
29	6a	" "	15	4	4	10	126	1¾	"	15	3–0	62½	......	11.3
	b			5½			173	1	"	15	1¾–0	..	......	...
	c			7			220	¾	"	15	1–0	..	......	...
	7a	" "	15	4	4	10	126	1¾	"	15	3–0	62½	......	11.3
	b			5½			173	1	"	15	1¾–0	..	......	....
	c			7			220	¾	"	15	1–0	..	......	...
32	8a	Roller cylindrical	16	5	6½	7	110	1¾	"	10	3½–¾	33	53	4.8
	b						110	2¾	"	6	3½–1¾	15	64	6.3
	9a	" "	16	5	6½	7	110	1¾	"	10	3½–¾	33	53	4.8
	b						110	2¾	"	6	3½–1¾	15	64	6.3
34	10a	Triple-jacketed, conical	16	5½ & 10	Axis level	8	195	1¾	"	16	3½–0	200	......	1.9
	b		15	7¾ & 12¼			251	1⅛	"	15	1¾–0	..	......	...
	c		14	10 & 14½			308	¾	"	14	1–0	..	......	...
	11a	Double-jacketed, cylindrical	5½	2½	4½	18	141	3	"	5½	3½–1¾	..	......	...
	b		5	3½			198	1¾	"	5	3–1¾	..	(Supplementing Screen 10a)	...
35	12	Conical	7	5 & 6	Axis level	11	190	¾	"	7	3–0	125	36	1.0
Average						13	219							4.2

(b) RESIZING WASHED COAL SIZED PRIOR TO WASHING

Wash-ery No.	Screen No.	Type	Length (Feet)	Dia. (Feet)	Slope (Degrees)	R. P. M.	Peripheral Speed Feet per Minute	Diam. (Ins.)	Shape	Length of Screening Surface (Feet)	Feed Diameter (Inches)	Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
2	13	Cylindrical	8	4	3	20	251	¾	Square	8	1⅛–¾	9	(Breakage only)	11.1
19	14	"	7	3	3	15	141	1¾	Round	7	3–1¾	6	" "	11.0
	15	"	7	3	3	15	141	1¾	"	7	3–1¾	6	" "	11.0
	16	"	7	3	3	15	141	1	"	7	1¾–1	14	" "	4.7
	17	"	7	3	3	15	141	1	"	7	1¾–1	14	" "	4.7

III. (b) RESIZING WASHED COAL SIZED PRIOR TO WASHING—Continued

Washery No.	Screen No.	Type	Length (Feet)	Dia. (Feet)	Slope (Degrees)	R. P. M.	Peripheral Speed Feet per Minute	Openings		Length of Screening Surface (Feet)	Feed		Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
								Diam. (Ins.)	Shape		Diameter (Inches)	Tons per Hour		
19	18	Cylindrical	7	3	3	15	141	½	Round	7	1–¾	28	(Breakage only)	2.4
	19	"	7	2½	3	15	118	¾	"	7	. . .	. .	" "	. . .
	20	"	8	4	4	18	226	¼	"	8	¾ & ½–0	52	50	1.9
20	21a	"	19½	6	4½	12	226	¾	"	6	3–$\frac{9}{16}$ sq.	53	(Very little)	2.6
	b							1⅛	"	8	3–¾	53	29	2.8
	c							1¾	"	5½	3–1⅛	39	49	2.7
	22a	Roller cylindrical	16	5	4	16	251	¼	"	12	¾ & $\frac{9}{16}$ sq.–0	58	56	4.3
	b							⅜	"	4	¾ & $\frac{9}{16}$ sq.–¼			
	23	Cylindrical	8	3	2½	36	339	¾	"	8	1⅛–¾	16	(Supplementing Screen No. 21a)	4.7
	24	"	8	3	2½	36	339	1⅛	"	8	1¾–1⅛	20	(Supplementing Screen No. 21b)	3.8
	25	"	8	3	2½	36	339	1¾	"	8	3–1¾	19	(Supplementing Screen No. 21c)	4.0
	26	"	8	4	2½	36	452	¼	"	8	¾–¼ & ⅜	32	(Supplementing Screen No. 22a)	3.1
24	27	"	8½	3	5	24	226	1¾	"	8½	3–1¾	9	(Breakage only)	9.0
	28	"	8½	3	5	24	226	1¾	"	8½	3–1¾	9	" "	9.0
	29	"	8½	3	5	24	226	1¾	"	8½	1¾–1	9	" "	9.0
	30	"	8½	3	5	24	226	1¾	"	8½	1¾–1	9	" "	9.0
	31	"	8½	3	5	24	226	¾	"	8½	1–¾	15	" "	5.3
	32	"	6½	3	5	24	226	1	"	6½	1¾–1	18	(Supplementing Nos. 27 & 28)	3.5
	33	"	10½	4	3½	30	377	¼	"	10½	¾–0	50	36	2.6
28	34a	Double-jacketed, cylindrical	5½	2	2½	15	94	1	"	5½	3–2	6	(Breakage only)	5.8
	b			3			141	¾	"	5½			" "	
	35	Cylindrical	7	2	5	15	94	¾	"	7	2–1	5	" "	8.8
	36a	Double-jacketed, cylindrical	5½	2	3	15	94	1	"	5½	2–1	12	" "	2.9
	b			3			141	¾	"	5½				
	37	Cylindrical	7	2	5	15	94	¾	"	7	1–¾	5	" "	8.8
	38	"	8	4	5	24	301	¼	"	8	¾–0	32	36	3.1
30	39a	Double-jacketed, cylindrical	. .	. .	. . . .	15	. . .	¾	"	8	3¾–¼	. .	. . . . . .	. . .
	b							1	"	. .	3¾–¾	. .	. . . . . .	. . .
	c							1¾	"	. .	3¾–1	. .	. . . . . .	. . .
32	40a	Double-jacketed, cylindrical	7	3	6	14	132	2½	"	7	3½–2¾		(Breakage only)	
	b			2			88	¾	"	7		5	" "	8.8
	41a	" "	7	3	6	14	132	2½	"	7	3½–2¾		" "	8.8
	b			2			88	¾	"	7		5	" "	8.8
	42a	" "	7	3	7	14	132	1¾	"	7	2¾–1¾		" "	

III. (b) RESIZING WASHED COAL SIZED PRIOR TO WASHING (Continued)

Washery No.	Screen No.	Type	Length (Feet)	Dia. (Feet)	Slope (Degrees)	R. P. M.	Peripheral Speed Feet per Minute	Openings		Length of Screening Surface (Feet)	Feed		Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
								Diam. (Ins.)	Shape		Diameter (Inches)	Tons per Hour		
32	b	Double-jack-		2			88	3/4	Round	7		6	(Breakage only)	7.4
	43a	eted, cylin-	7	3	7	14	132	1 3/4	"	7	2 3/4–1 3/4		" "	
	b	drical		2			88	3/4	"	7		6	" "	7.4
	44a	" "	7	3	7	14	132	1 3/4	"	7	2 3/4–1 3/4		" "	
	b			2			88	3/4	"	7		6	" "	7.4
	45a	" "	7	3	7 1/2	14	132	1 3/8	"	7	1 3/4–3/4		" "	
	b			2			88	7/8	"	7		9	" "	4.9
	46a	" "	7	3	7 1/2	14	132	1 3/8	"	7	1 3/4–3/4		" "	
	b			2			88	7/8	"	7		9	" "	4.9
	47a	" "	7	3	7 1/2	14	132	1 3/8	"	7	1 3/4–3/4	9	" "	
	b			2			88	7/8	"	7		9	" "	4.9
	48	Conical	10	4 & 5	Axis level	15	212	1/4	"	10	3/4–0 }	54	42	3.8
	49	"	6	3 & 4	" "	24	264	3/8	"	6	3/4–0 }			
34	50a	Triple-jack-	7	2 1/2	3 1/2	24	188	2 1/4	"	7	3 1/2–3	..	(Breakage only)	...
	b	eted, cylin-	6	3 1/6			264	1 1/2	"	6				
	c	drical	5	4 1/2			339	3/4	"	5				
	51a	" "	7	3 1/2	3 1/2	24	264	2 1/4	"	7	3–1 3/4	..	" "	...
	b		6	4 1/2			339	1 1/2	"	6				
	c		5	5 1/2			414	3/4	"	5				
	52a	Double-jack-	7	2 1/4	3 1/2	24	170	1 3/16	"	7	1 3/4–1 1/8	..	" "	...
	b	eted, cylin-	6	3 1/8			239	3/4	"	6				
	53a	drical	7	2 1/4	3 1/2	24	170	1 3/16	"	7	1 3/4–1 1/8	..	" "	...
	b	"	6	3 1/6			239	3/4	"	6				
	54	Cylindrical	7	3 1/6	3 1/2	24	239	3/4	"	7	1 1/8–3/4	..	" "	...
	55	Cylindrical	7	3 1/6	3 1/2	24	239	3/4	"	7	1 1/8–3/4	..	" "	...
	56		8	5	1	12	188	5/16	"	8	3/4–0	..	......	...
35	57a	Double-jack-	20	5 & 8	Axis level	14	252	1	"	9	3–0	119	27	1.4
	b	eted, conical					319	{ 1 1/4	"	5 1/2	3–1 }	87	25	2.9
								{ 2	"	5 1/2	3–1 1/4 }	87	25	2.9
	c			7 & 8 1/2		340				9	1–0	65	34	3.4
Average						20	202							5.66

(c) SIZING WASHED COAL

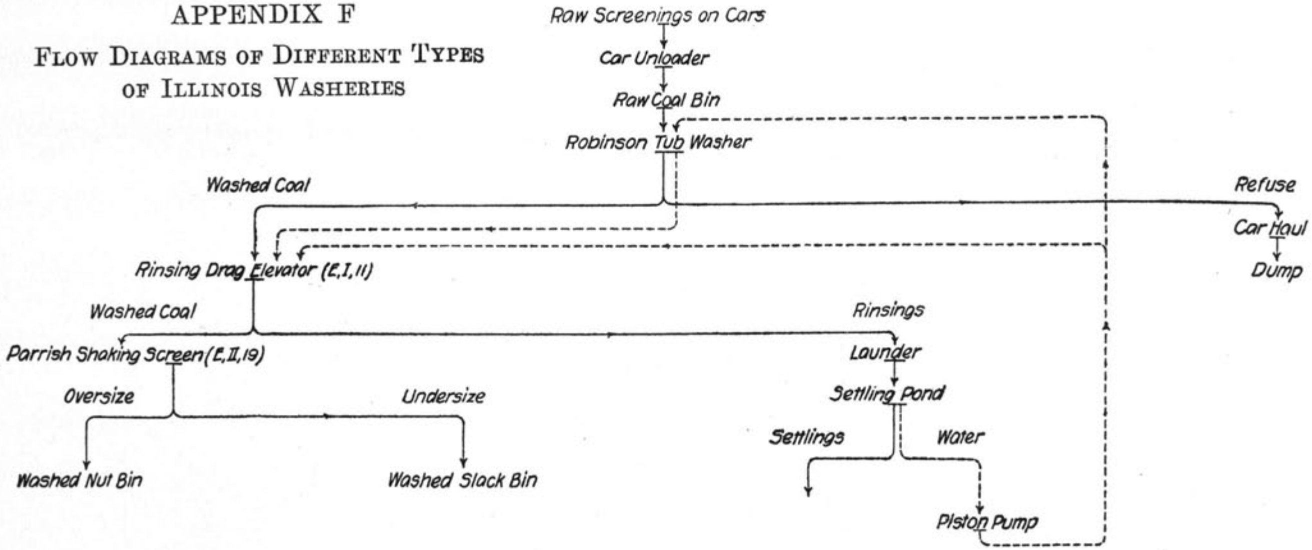
Washery No.	Screen No.	Type	Length (Feet)	Dia. (Feet)	Slope (Degrees)	R. P. M.	Peripheral Speed Feet per Minute	Openings Diam. (Ins.)	Openings Shape	Length of Screening Surface (Feet)	Feed Diameter (Inches)	Feed Tons per Hour	Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
1	58	Cylindrical	10	4 1/2	5	14	196	3/4	Square	10	1 1/8–0	34	90	4.2
4	59a	"	23 1/2	4	5	22	182	3/32	Round	10	1 1/2–0	67	(Rinsings only)	1.9
	b	"						7/8	Square	8	1 1/2–3/32	67	76	1.5
	c	"						1 3/8	"	5 1/2	1 1/2–7/8	16	90	4.3
5	60	Conical	10	2 1/2 & 3	Axis 2 1/2	48	396	2	Round	5	2 1/2–0	19	21	2.3
6	61	Cylindrical	12	3	3 1/2	20	188	1 1/4	"	12	2 1/2 & 2 1/4–1/16	38	80	3.0
7	62	"	12	3	3 1/2	20	188	1 1/4	"	12	1 1/2 slot–1/16	30	......	3.8
9	63	"	10	5	4	21	330	5/16	"	10	3–0	81	32	1.9
12	64	"	14	5	2 1/2	15	236	5/16	"	14	3–0	..	....	...

III. (c) SIZING WASHED COAL (Continued)

Washery No.	Screen No.	Type	Length (Feet)	Dia. (Feet)	Slope (Degrees)	R. P. M.	Peripheral Speed Feet per Minute	Openings		Length of Screening Surface (Feet)	Feed		Per Cent Through Screen	Sq. Ft. Screen Per Ton per Hour
								Diam. (Ins.)	Shape		Diameter (Inches)	Tons per Hour		
13	65	Cylindrical	9⅓	4⅔	5½	40	588	5/16	Round	9⅓	3½–0	..	......	...
14	66	"	10	5	4	14	220	¼	"	10	3½–0	108	......	1.5
	67a	Double-jacketed, conical	21	5 & 8	Axis level	15	267	1⅜	"	9	3½–¼	..	......	...
	b						315	1	Square	6	3½–1⅜	..	......	...
	c						356	1¾	"	6	3½–1 sq.	..	......	...
	d		9	7 & 8⅓			362	⅞	Round	9	1⅜–¼	..	......	...
15	68	Cylindrical	9⅓	4	5	20	251	⅜	"	9⅓	⅝–0	..	......	...
16	69	Conical	6½	4 & 5	Axis level	25	353	5/16	"	6½	3–0	..	......	...
17	70	Roller	16	6	5	12	226	⅜	"	16	1¼–0	125	39	2.4
	71	cylindrical	16	6	5	12	226	⅜	"	16	1¼–0	125	39	2.4
18	72	Cylindrical	12	4	5	20	251	¼	"	12	¾–0	61	48	
	73	"	7	3	7	11½	108	1½	"	7	3–1¾	109	(Supplementing Shaker Screen No. 27)	0.6
	74	"	7	3	7	11½	108	1	"	7	1¾–1⅛	94	" "	0.7
	75	"	7	3	7	11½	108	⅜	"	7	1⅛–¾	74	" "	0.9
22	76a	"	18	5	4	18	283	¾	"	12	3–0	113	61	1.7
	b							1¾	"	6	3–¾	44	3	2.2
	77	"	12	5	3	18	283	⅜	"	12	¾–0	69	62	2.7
	78	"	12	4	2	21	265	1/16	"	12	⅜–0	43	(Rinsings only)	3.5
	79	"	8	4	5	15	180	1¾	"	8	3–1¾	1	(Supplementing Screen No. 76b)	100.
	80	"	7	3	7	15	141	1⅛	"	7	1¾–¾	22	50	3.0
	81	"	7	4	7	15	188	1⅛	"	7	1¾–¾	22	50	3.0
	82	"	8	4	4	18	226	{ ¾	"	4 }	..	..	(Supplementing Screen No. 76c)	
								1	"	4				...
23	83	"	12	5	5	16	251	⅜	"	12	¾–0	28	36	6.7
	84	"	12	5	5	16	251	⅜	"	12	¾–0	28	36	6.7
26	85a	"	16	4	5	18	226	2	"	8	2½–0	..	......	...
	b							1¼	"	8	2–0	..	......	...
27	86	"	8	4	4½	20	251	¾	"	8	3–0	..	......	...
	87a	"	12	4	5	18	226	2	"	6	3–¾	..	......	...
	b							1¾	"	3	2–¾	..	......	...
	c							1	"	3	1¾–¾	..	......	...
31	88a	Triple-jacketed, conical	15	4 & 7½	Axis level	12	216	1¾	Round	15	3–7/16 & ⅜	114	69	2.4
	b		16	6½ & 10			311	1¼	"	16	1¾–7/16 & ⅜	78	51	5.3
	c		17	8 & 12			377	¾	"	17	1¼–7/16 & ⅜	50	67	10.7
	89	Cylindrical	11	3	8	20	188	¾	"	11	1¼–¾	16	(Supplementing Screen No. 88c)	6.5
33	90a	Triple-jacketed, conical	14	4 & 6	Axis level	8½	133	1¾	"	14	3½–0	106	24	2.1
	b			6 & 8			188	1	"	14	1¾–0	81	28	3.8
	c			7½ & 9½			227	¾	"	14	1–0	58	27	6.4
	91	Cylindrical	8	4	4	16	201	5/16 & ¼	"	8	¾–0	21	45	4.8
	92	"	8	4	4	16	201	5/16 & ¼	"	8	¾–0	21	45	4.8
Average	......					18	245	......						6.5

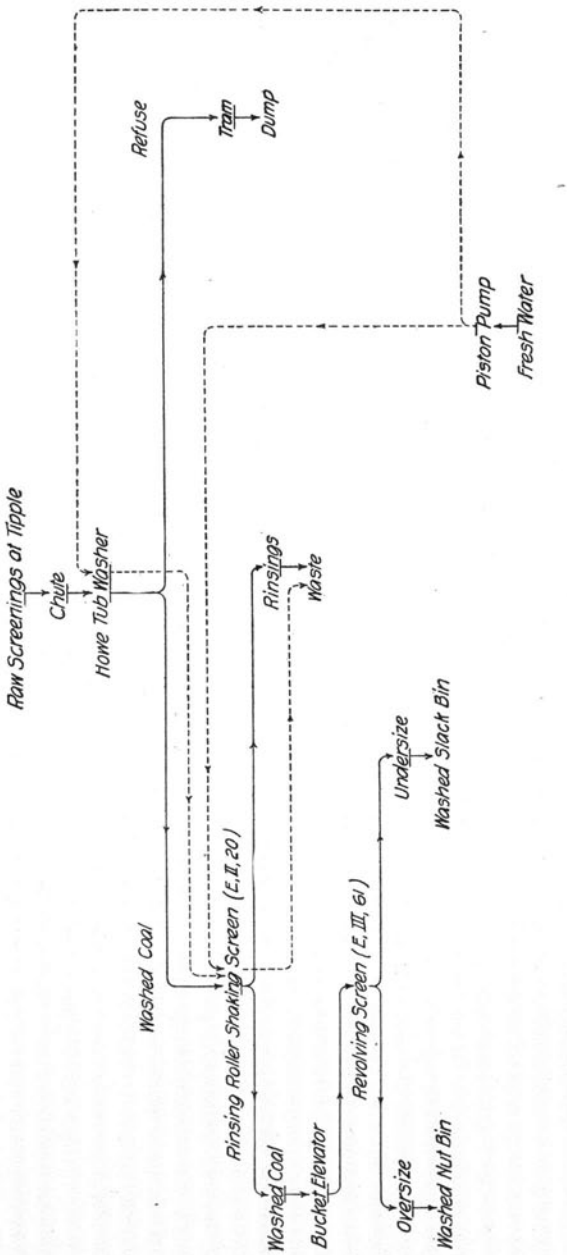
APPENDIX F

Flow Diagrams of Different Types of Illinois Washeries



Note - Course of coal shown in full lines. Course of water in broken lines. The references in parentheses after screens are to Appendix E where the screens are described in detail.

Fig. 18. Flow Sheet of a Robinson Tub Washery (No. 3)



Note—Course of coal shown in full lines. Course of water in broken lines. The references in parentheses after screens are to Appendix E where the screens are described in detail.

FIG. 19. FLOW SHEET OF A HOWE TUB WASHERY (NO. 6)

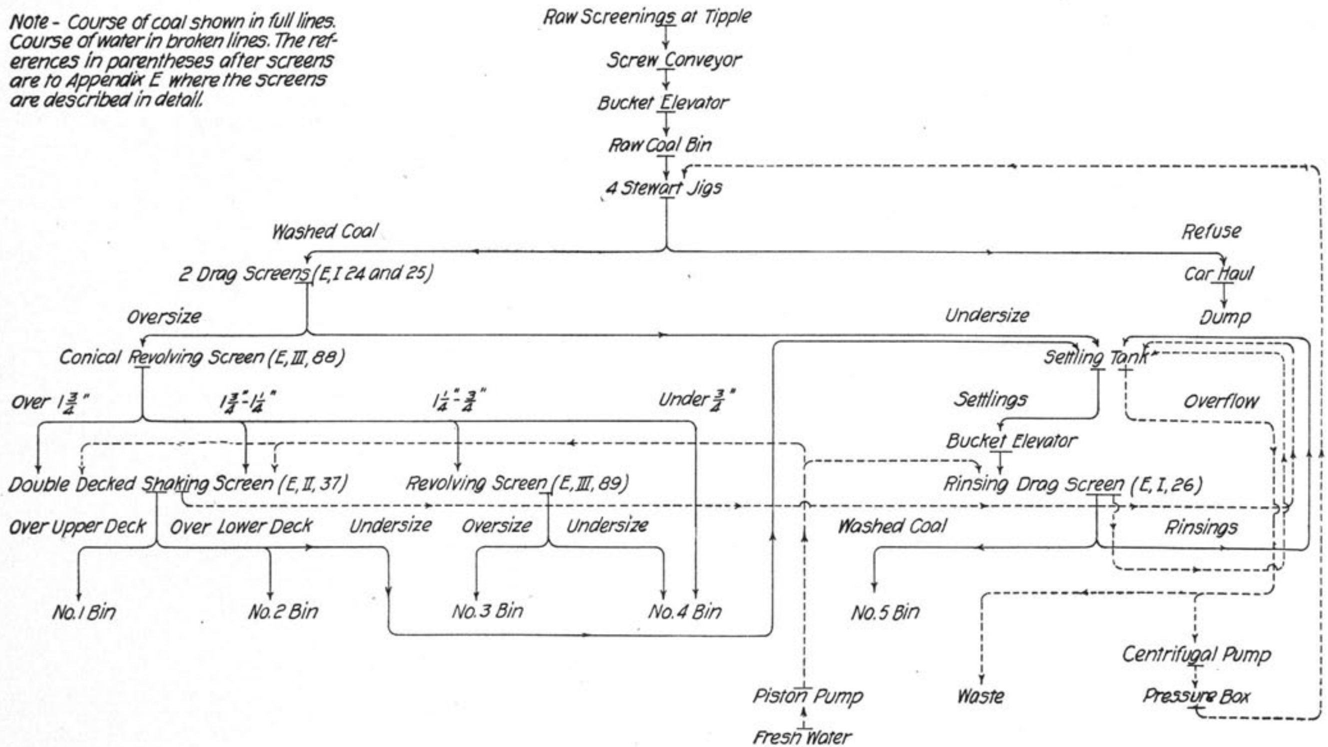
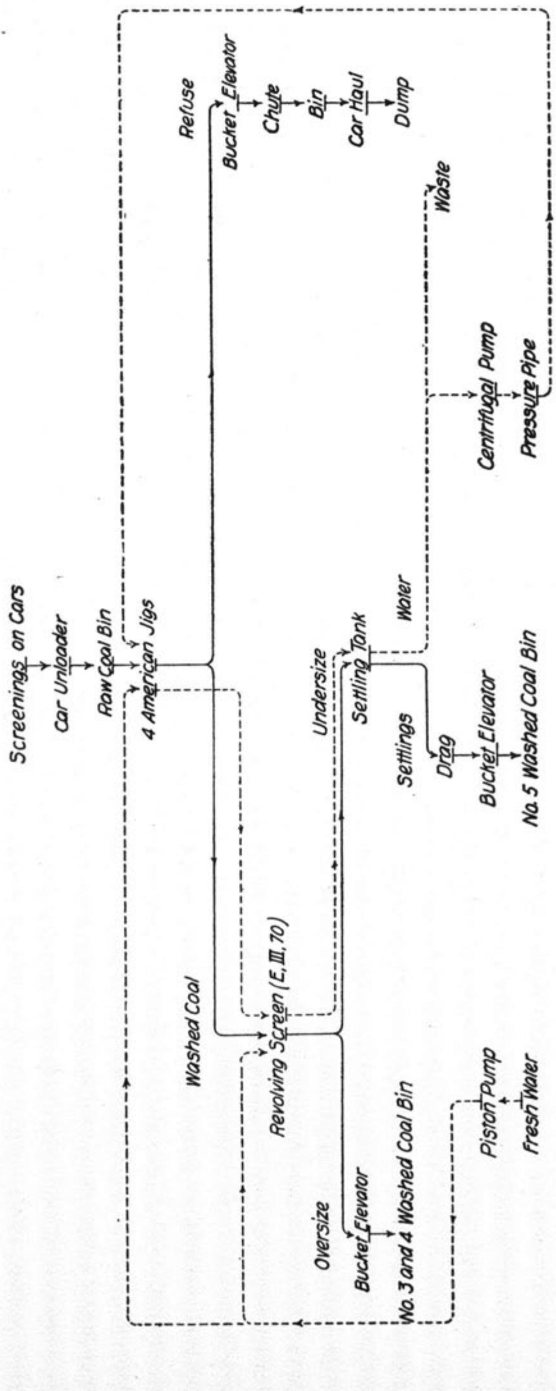
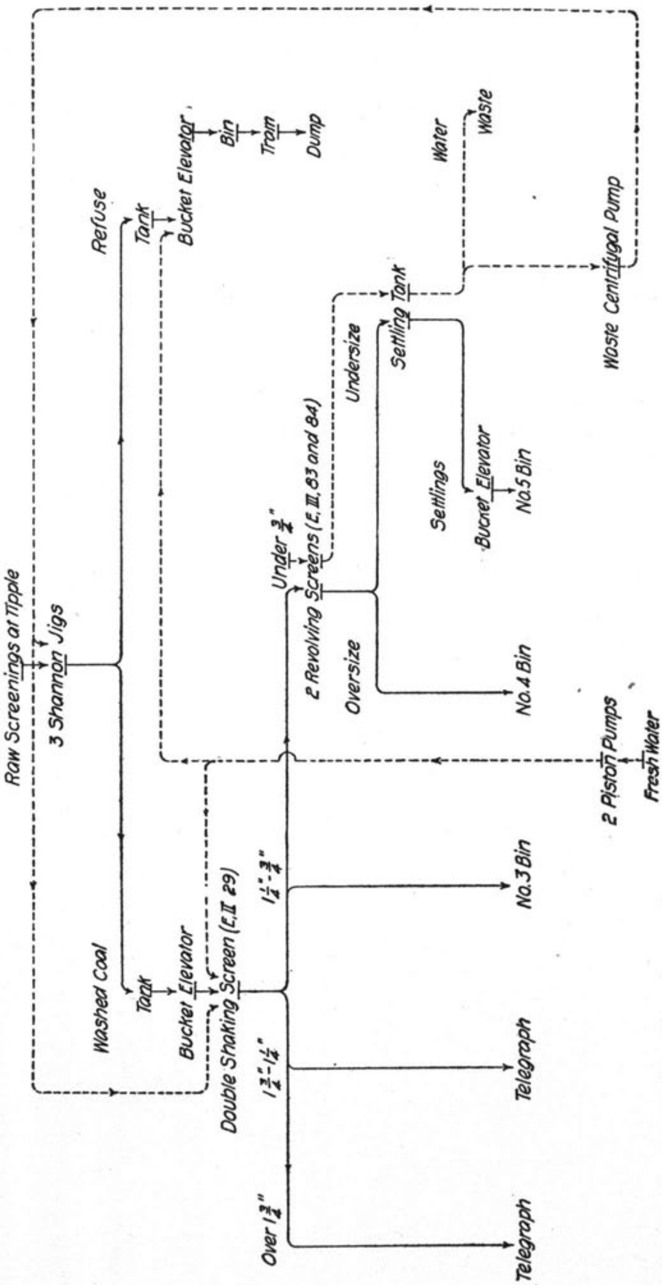


FIG. 20. FLOW SHEET OF A STEWART PAN JIG WASHERY (No. 31)



Note—Course of coal shown in full lines. Course of water in broken lines. The references in parentheses after screens are to Appendix E where the screens are described in detail.

FIG. 21. FLOW SHEET OF AN AMERICAN PAN JIG WASHERY



Note - Course of coal shown in full lines. Course of water in broken lines. The references in parentheses are to Appendix E where the screens are described in detail.

FIG. 22. FLOW SHEET OF A SHANNON PAN JIG WASHERY (No. 23)

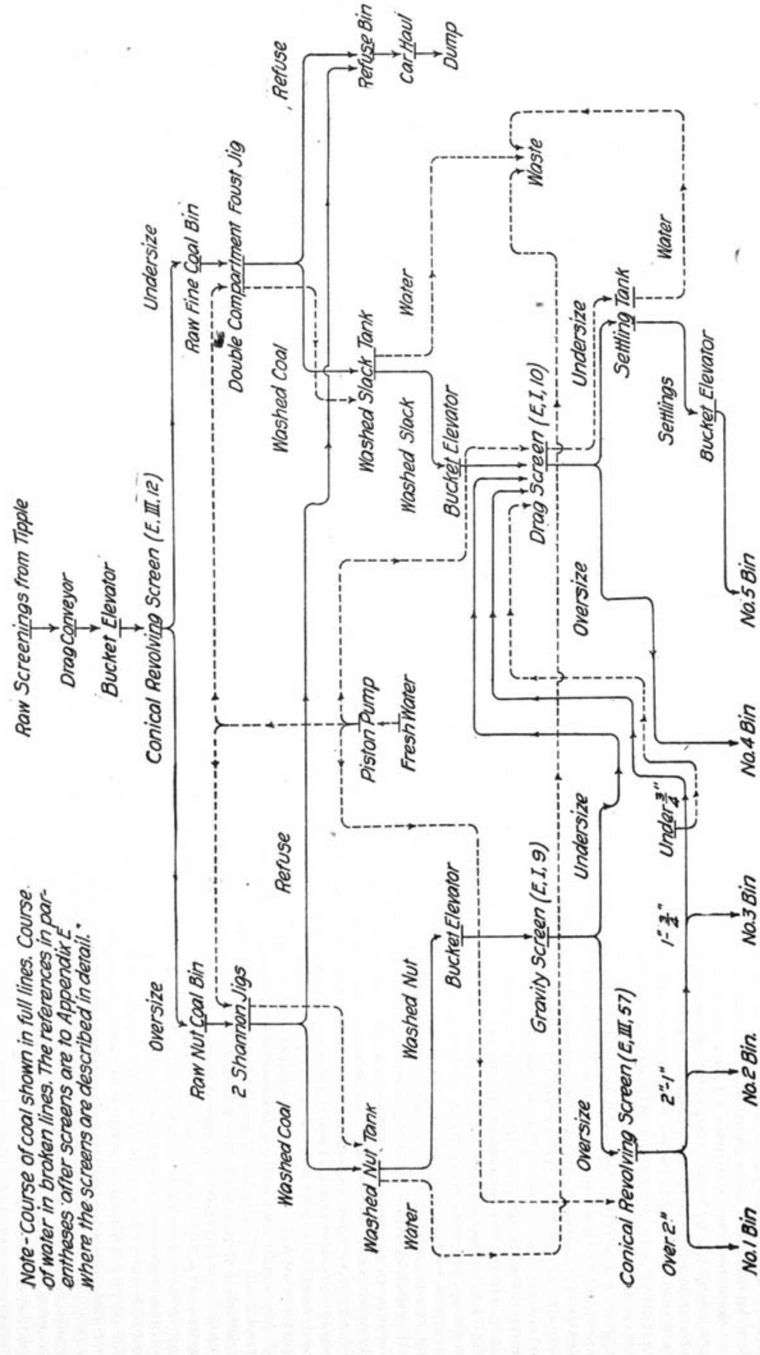


FIG. 23. FLOW SHEET OF A SHANNON AND FOUST JIG WASHERY (No. 35)

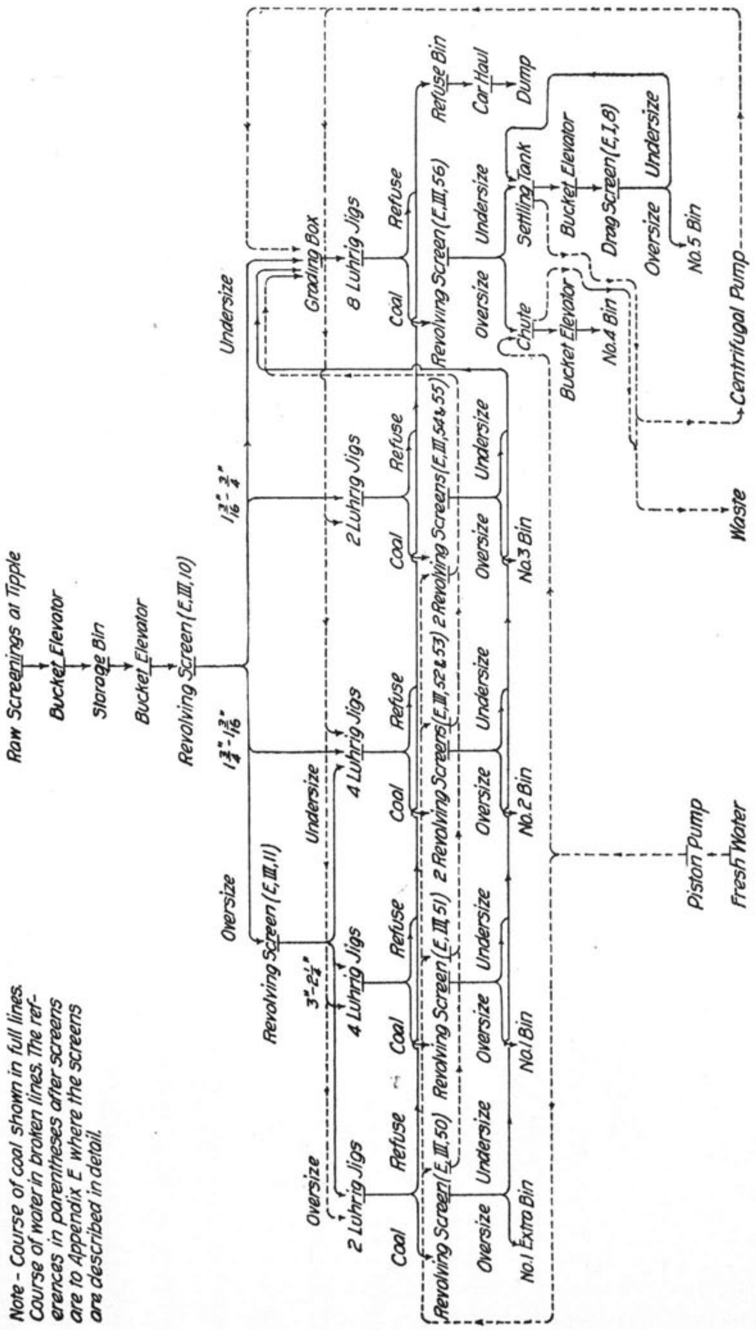


FIG. 24. FLOW SHEET OF A LUHRIG PISTON JIG WASHERY (No. 34)

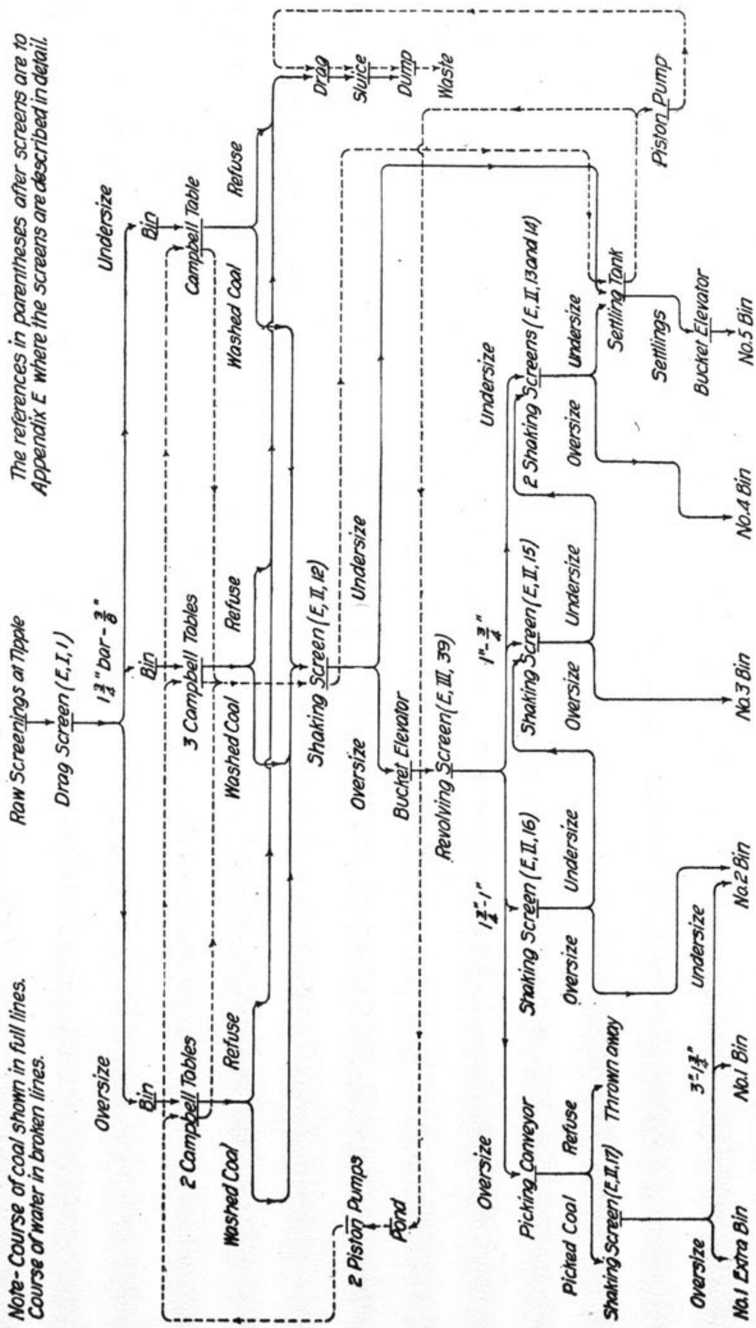


FIG. 25. FLOW SHEET OF A CAMPBELL BUMPING TABLE WASHERY (No. 30)

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